

**Draft Environmental Analysis of a  
Marine Geophysical Survey  
by the R/V *Marcus G. Langseth*  
in the South Atlantic Ocean,  
Austral Summer 2016**

Prepared for

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## ABSTRACT

Researchers from Texas A&M University and the University of Texas, with funding from the U.S. National Science Foundation (NSF), propose to conduct a high-energy seismic survey from the Research Vessel (R/V) *Marcus G. Langseth* (*Langseth*) from the Mid-Atlantic Ridge (MAR) to the Rio Grande Rise in the South Atlantic Ocean for an approximate 42-day period in austral summer 2016. The NSF-owned *Langseth* is operated by Columbia University's Lamont-Doherty Earth Observatory (L-DEO) under an existing Cooperative Agreement. The proposed seismic survey would use a towed array of 36 airguns with a total discharge volume of ~6600 in<sup>3</sup>. The survey would take place in International Waters in water depths 1150–4800 m.

NSF, as the funding and action agency, has a mission to “promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense...”. The proposed seismic survey would collect data in support of a research proposal that has been reviewed under the NSF merit review process and identified as an NSF program priority. It would provide data necessary to study the evolution of the South Atlantic oceanic crust.

This Draft Environmental Analysis (EA) addresses NSF's requirements under Executive Order 12114, “Environmental Effects Abroad of Major Federal Actions”, for the proposed NSF federal action. As operator of the *Langseth*, L-DEO, on behalf of itself, NSF, Texas A&M University, and the University of Texas, is requesting an Incidental Harassment Authorization (IHA) from the U.S. National Marine Fisheries Service (NMFS) to authorize the incidental, i.e., not intentional, harassment of small numbers of marine mammals should this occur during the seismic survey. The analysis in this document supports the IHA application process and provides information on marine species that are not addressed by the IHA application, including sea turtles, seabirds, fish, and invertebrates that are listed under the U.S. Endangered Species Act (ESA), including candidate species. As analysis on endangered/threatened species was included, this document will also be used to support ESA Section 7 consultations with NMFS and the U.S. Fish and Wildlife Service (USFWS). Alternatives addressed in this EA consist of a corresponding program at a different time with issuance of an associated IHA and the No Action alternative, with no IHA and no seismic survey. This document tiers to the Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey (June 2011) and Record of Decision (June 2012), referred to herein as PEIS.

Numerous species of marine mammals inhabit the South Atlantic Ocean. Several of these species are listed as **Endangered** under the ESA: the southern right, humpback, sei, fin, blue, and sperm whales. Other marine ESA-listed species that could occur in the area include the **Endangered** leatherback and hawksbill turtles; the **Threatened** green, loggerhead, and olive ridley turtles; the **Endangered** freira; and the **Endangered** scalloped hammerhead shark. ESA-listed **candidate species** that could occur in the area are the Argentine angelshark, angular angelshark, common thresher shark, porbeagle shark, narrownose smooth-hound shark, and Brazilian guitarfish.

Potential impacts of the proposed seismic survey on the environment would be primarily a result of the operation of the airgun array. A multibeam echosounder and sub-bottom profiler would also be operated during the survey. Impacts would be associated with increased underwater noise, which could result in avoidance behavior by marine mammals, sea turtles, seabirds, and fish, and other forms of disturbance. An integral part of the planned survey is a monitoring and mitigation program designed to minimize potential impacts of the proposed activity on marine animals present during the proposed

survey, and to document as much as possible the nature and extent of any effects. Injurious impacts to marine mammals, sea turtles, and seabirds have not been proven to occur near airgun arrays or the other types of sound sources to be used. However, a precautionary approach would still be taken, and the planned monitoring and mitigation measures would reduce the possibility of any effects.

Protection measures designed to mitigate the potential environmental impacts to marine mammals and sea turtles would include the following: ramp ups; two dedicated observers maintaining a visual watch during all daytime airgun operations; two observers before and during ramp ups during the day; no start ups during poor visibility or at night unless at least one airgun has been operating; passive acoustic monitoring (PAM) via towed hydrophones during both day and night to complement visual monitoring; and power downs (or if necessary shut downs) when marine mammals or sea turtles are detected in or about to enter designated exclusion zones. The acoustic source would also be powered or shut down in the event an ESA-listed seabird were observed diving or foraging within the designated exclusion zones. Observers would also watch for any impacts the acoustic sources may have on fish. L-DEO and its contractors are committed to applying these measures in order to minimize effects on marine mammals, sea turtles, seabirds, and fish, and other potential environmental impacts.

With the planned monitoring and mitigation measures, unavoidable impacts to each species of marine mammal and sea turtle that could be encountered would be expected to be limited to short-term, localized changes in behavior and distribution near the seismic vessel. At most, effects on marine mammals could be interpreted as falling within the MMPA definition of “Level B Harassment” for those species managed by NMFS. No long-term or significant effects would be expected on individual marine mammals, sea turtles, seabirds, fish, the populations to which they belong, or their habitats.

## LIST OF ACRONYMS

|       |   |
|-------|---|
| ~     | approximately   |
| 2-D   | two-dimensional   |
| 3-D   | three-dimensional                                       |
| AEP   | Auditory Evoked Potential                               |
| AMVER | Automated Mutual-Assistance Vessel Rescue               |
| CITES | Convention on International Trade in Endangered Species |
| dB    | decibel   |
| DNA   | Deoxyribonucleic Acid                                   |
| DPS   | Distinct Population Segment                             |
| DSDP  | Deep Sea Drilling Project                               |
| EA    | Environmental Analysis                                  |
| EFH   | Essential Fish Habitat                                  |
| EIS   | Environmental Impact Statement                          |
| EO    | Executive Order   |
| ESA   | (U.S.) Endangered Species Act                           |
| EZ    | Exclusion Zone  |
| FAO   | Food and Agriculture Organization of the United Nations |
| FM    | Frequency Modulated                                     |
| GIS   | Geographic Information System                           |
| GoM   | Gulf of Mexico  |
| h     | hour  |
| HAPC  | Habitat Areas of Particular Concern                     |
| hp    | horsepower  |
| Hz    | Hertz   |
| IHA   | Incidental Harassment Authorization (under MMPA)        |
| in    | inch  |
| IOC   | Intergovernmental Oceanographic Commission of UNESCO    |
| IODP  | International Ocean Discovery Program                   |
| ITS   | Incidental Take Statement                               |
| IUCN  | International Union for the Conservation of Nature      |
| IWC   | International Whaling Commission                        |
| kHz   | kilohertz   |
| km    | kilometer   |
| kt    | knot  |
| L-DEO | Lamont-Doherty Earth Observatory                        |
| LFA   | Low-frequency Active (sonar)                            |
| m     | meter   |
| MAR   | Mid-Atlantic Ridge                                      |
| MBES  | Multibeam Echosounder                                   |
| MCS   | Multi-Channel Seismic                                   |
| MFA   | Mid-frequency Active (sonar)                            |
| min   | minute  |
| MMPA  | (U.S.) Marine Mammal Protection Act                     |
| MPA   | Marine Protected Area                                   |

|         |  |
|---------|--|
| ms      | millisecond  |
| n.mi.   | nautical mile  |
| NMFS    | (U.S.) National Marine Fisheries Service                         |
| NMSDD   | Navy Marine Species Density Database                             |
| NOAA    | National Oceanic and Atmospheric Administration                  |
| NRC     | (U.S.) National Research Council                                 |
| NSF     | National Science Foundation                                      |
| OAWRS   | Ocean Acoustic Waveguide Remote Sensing                          |
| OBIS    | Ocean Biogeographic Information System                           |
| OBS     | Ocean Bottom Seismometer   |
| OCS     | Outer Continental Shelf  |
| ODP     | Ocean Drilling Program   |
| OEIS    | Overseas Environmental Impact Statement                          |
| p or pk | peak   |
| PEIS    | Programmatic Environmental Impact Statement                      |
| PI      | Principal Investigator   |
| PTS     | Permanent Threshold Shift  |
| PSO     | Protected Species Observer                                       |
| RAF     | Royal Air Force  |
| RL      | Received level   |
| rms     | root-mean-square   |
| R/V     | research vessel  |
| s       | second   |
| SAUP    | Sea Around Us Project  |
| SBP     | Sub-bottom Profiler  |
| SEAFO   | South East Atlantic Fisheries Organization                       |
| SEFSC   | Southeast Fisheries Science Center                               |
| SEL     | Sound Exposure Level (a measure of acoustic energy)              |
| SPL     | Sound Pressure Level   |
| TTS     | Temporary Threshold Shift  |
| U.K.    | United Kingdom   |
| UNEP    | United Nations Environment Programme                             |
| UNESCO  | United Nations Educational, Scientific and Cultural Organization |
| U.S.    | United States of America   |
| USCG    | U.S. Coast Guard   |
| USGS    | U.S. Geological Survey   |
| USFWS   | U.S. Fish and Wildlife Service                                   |
| USN     | U.S. Navy  |
| μPa     | microPascal  |
| VME     | Vulnerable Marine Ecosystem                                      |
| vs.     | versus   |
| WCMC    | World Conservation Monitoring Centre                             |
| WHC     | World Heritage Convention  |

## **I PURPOSE AND NEED**

The purpose of this Draft Environmental Analysis (EA) is to provide the information needed to assess the potential environmental impacts associated with the proposed action, including the use of a 36-airgun array during the proposed seismic survey. This Draft EA was prepared under Executive Order 12114, “Environmental Effects Abroad of Major Federal Actions” (EO 12114). This Draft EA tiers to the Final Programmatic Environmental Impact Statement (PEIS)/Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the National Science Foundation or Conducted by the United States (U.S.) Geological Survey (NSF and USGS 2011) and Record of Decision (NSF 2012), referred to herein as the PEIS. The Draft EA provides details of the proposed action at the site-specific level and addresses potential impacts of the proposed seismic survey on marine mammals, sea turtles, seabirds, fish, and invertebrates. The Draft EA will also be used in support of an application for an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS), and Section 7 consultations under the Endangered Species Act (ESA). The IHA would allow the non-intentional, non-injurious “take by harassment” of small numbers of marine mammals<sup>1</sup> during the proposed seismic survey by Columbia University’s Lamont-Doherty Earth Observatory (L-DEO) in the South Atlantic Ocean during an approximate 42-day period in austral summer 2016.

### **1.1 Mission of NSF**

The National Science Foundation (NSF) was established by Congress with the National Science Foundation Act of 1950 (Public Law 810507, as amended) and is the only federal agency dedicated to the support of fundamental research and education in all scientific and engineering disciplines. Further details on the mission of NSF are described in § 1.2 of the PEIS.

### **1.2 Purpose of and Need for the Proposed Action**

As noted in the PEIS, § 1.3, NSF has a continuing need to fund seismic surveys that enable scientists to collect data essential to understanding the complex Earth processes beneath the ocean floor. The primary purpose of the proposed action is to collect two-dimensional (2-D) seismic data from the Mid-Atlantic Ridge (MAR) westward to the Rio Grande Rise to study the evolution of oceanic crust on million-year timescales and the evolution and stability of slow-spreading ridges over time. The collection of both reflection and refraction seismic data would provide for a continuous characterization of slow-to-intermediate spread oceanic crust from the active spreading center to crust formed (approximately) ~70 million years ago. Additionally, the proposed survey would provide seismic data for five sites proposed for future drilling by the International Ocean Discovery Program (IODP). The proposed activity would collect data in support of a research proposal that has been reviewed under the NSF merit review process and identified as an NSF program priority to meet NSF’s critical need to foster an understanding of Earth processes.

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<sup>1</sup> To be eligible for an IHA under the MMPA, the proposed “taking” (with mitigation measures in place) must not cause serious physical injury or death of marine mammals, must have negligible impacts on the species and stocks, must “take” no more than small numbers of those species or stocks, and must not have an unmitigable adverse impact on the availability of the species or stocks for legitimate subsistence uses.

### 1.3 Background of NSF-funded Marine Seismic Research

The background of NSF-funded marine seismic research is described in § 1.5 of the PEIS.

### 1.4 Regulatory Setting

The regulatory setting of this EA is described in § 1.8 of the PEIS, including the

- Executive Order 12114;
- Marine Mammal Protection Act (MMPA); and
- Endangered Species Act (ESA).

## II ALTERNATIVES INCLUDING PROPOSED ACTION

In this Draft EA, three alternatives are evaluated: (1) the proposed seismic survey and associated issuance of an associated IHA, (2) a corresponding seismic survey at an alternative time, along with issuance of an associated IHA, and (3) No Action alternative. Additionally, two alternatives were considered but were eliminated from further analysis. A summary of the proposed action, alternatives, and alternatives eliminated from further analysis is provided at the end of this section (Table 2).

### 2.1 Proposed Action

The project objectives and context, activities, and monitoring/mitigation measures for the proposed seismic survey are described in the following subsections.

#### 2.1.1 Project Objectives and Context

Researchers from Texas A&M University and University of Texas at Austin propose to conduct a 2-D seismic survey using L-DEO's Research Vessel (R/V) *Marcus G. Langseth (Langseth)* on the MAR in the South Atlantic Ocean (Fig. 1). The main goal of the proposed research is to collect and analyze reflection and refraction seismic data from the MAR to the Rio Grande Rise to study the evolution of the South Atlantic Ocean crust. Multi-channel seismic (MCS) surveys and ocean bottom seismometer (OBS) profiles would be used to acquire reflection and refraction data, respectively. The survey would also provide essential IODP site survey information for five proposed drill sites spanning the same transect; although information from the proposed activity would help inform the location of potential drill sites, should it go forward, the IODP activity would be an independent and separately funded activity. The resulting seismic data would address questions about the evolution of the ocean crust and the evolution and stability of slow-spreading ridges over time.

The goal of the MCS operations is to image changes in crustal structure from the MAR to aging crust to the west, as well as the increasing sedimentary cover and potential effects on crustal properties. The OBS profiles would acquire refraction data at five different sites with various half spreading rates: two with half spreading rates of 24–25 mm/year, two with 19.5 mm/year, and one with 15 mm/year. Profiles would be shot in the ridge-parallel direction to allow sampling of crust formed at the same age and at the same spreading rate along each line to characterize the structure of the crust and upper mantle. To achieve the project's goals, the Principal Investigator (PI) Dr. R. Reece (Texas A&M University) and co-PIs Drs. G. Christeson (University of Texas at Austin) and R. Carlson (Texas A&M University) propose to collect 2-D MCS reflection data along one main transect line between the MAR and Rio Grande Rise and five short crossline transects coincident with OBS profiles and the proposed IODP drill sites.

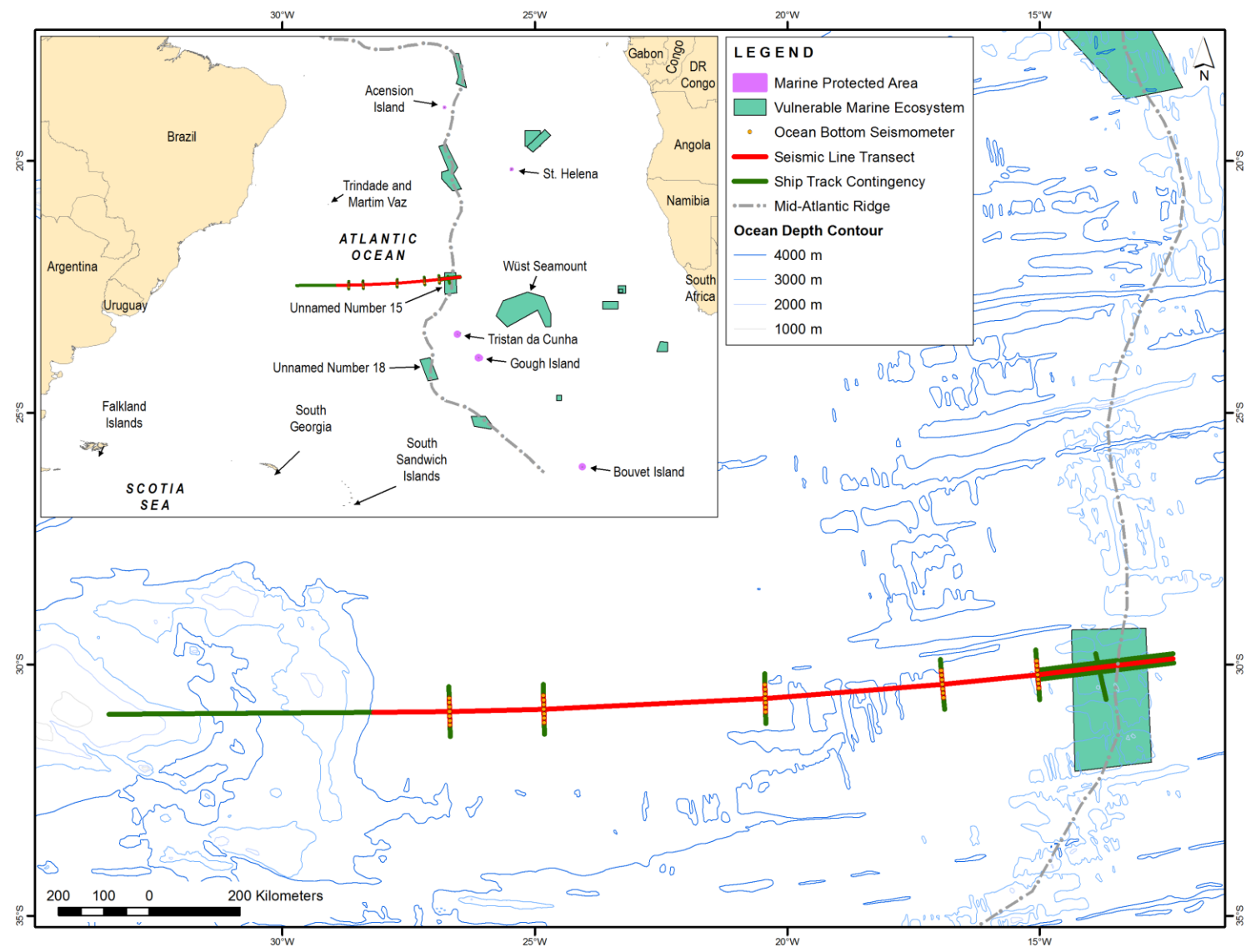


Figure 1. Location of the proposed seismic survey in the South Atlantic Ocean during austral summer 2016. Also shown are marine protected areas, vulnerable marine ecosystems, and the approximate location of the Mid-Atlantic Ridge (see § III for details).

## 2.1.2 Proposed Activities

### 2.1.2.1 Location of the Activities

The proposed survey would occur within the area ~10–35°W, 27–33°S (Fig. 1). Water depths in the survey area range from ~1150 to 4800 m. The proposed seismic survey would be conducted within International Waters of the South Atlantic Ocean.

### 2.1.2.2 Description of Activities

The procedures to be used for the marine geophysical survey would be similar to those used during previous surveys by L-DEO and would use conventional seismic methodology. The survey would involve one source vessel, the *Langseth*. The *Langseth* would deploy an array of 36 airguns as an energy source with a total volume of ~6600 in<sup>3</sup>. The receiving system would consist of seven OBSs deployed at each of five sites and a single 8-km hydrophone streamer. As the airgun array is towed along the survey lines, the OBSs would receive and store the returning acoustic signals internally for later analysis, and the hydrophone streamer would transfer the data to the on-board processing system.

A total of 3263 km of transect lines would be surveyed in the South Atlantic Ocean, including 2127 km of primary transect lines and 1136 km of contingency transect lines, if time allows (Fig. 1). There could be additional seismic operations associated with turns, airgun testing, and repeat coverage of any areas where initial data quality is sub-standard.

In addition to the operations of the airgun array, a multibeam echosounder (MBES) and a sub-bottom profiler (SBP) would also be operated from the *Langseth* continuously throughout the survey. All planned geophysical data acquisition activities would be conducted by L-DEO with on-board assistance by the scientists who have proposed the study. The vessel would be self-contained, and the crew would live aboard the vessel.

### 2.1.2.3 Schedule

The survey is proposed to be conducted for ~42 days in austral summer 2016. The seismic program would take ~32 days, including ~22 days of seismic surveying and 10 days of OBS deployment/retrieval. The *Langseth* would depart from and return to Montevideo, Uruguay; round-trip transit from port to the proposed survey area would be ~10 days. Some deviation in the schedule and port locations are possible, depending on logistics and weather. A change in the survey timing, including to a different season, would not affect the ensuing analysis (including take estimates), because the best available species densities for any time of the year have been used.

### 2.1.2.4 Vessel Specifications

The *Langseth* is described in § 2.2.2.1 of the PEIS. The vessel speed during seismic operations would be ~4.5 kt (~8.3 km/h).

### 2.1.2.5 Airgun Description

During the survey, the *Langseth* full array, consisting of four strings with 36 airguns (plus 4 spares) and a total volume of ~6600 in<sup>3</sup>, would be used. The airgun arrays are described in § 2.2.3.1 of the PEIS, and the airgun configurations are illustrated in Figures 2-11 to 2-13 of the PEIS. The 4-string array would be towed at a depth of 9 m; the shot intervals would range from 65 s (150 m) for OBS lines and ~22 s (50 m) for MCS surveying with the streamer.

### 2.1.2.6 OBS Description and Deployment

The *Langseth* would deploy seven OBSs at a 10-km spacing (with a total profile length of 60 km) at each of five sites. OBS operations would be carried out from west to east. For each of the five OBS profiles, seven OBSs would be deployed followed by the source array, the line would be surveyed, and the source array and OBSs would then be recovered before moving to the next line. It is proposed that the hydrophone streamer and airgun array would be deployed for MCS operations from east to west after all OBS operations are finished. However, MCS surveying may occur before OBS operations.

The OBSs that would be used during the cruise could include Woods Hole Oceanographic Institute (WHOI) and Scripps Institution of Oceanography (SIO) OBSs. The WHOI D2 OBSs have a height of ~1 m and a maximum diameter of 50 cm. The anchor is made of hot-rolled steel and weighs 23 kg. The anchor dimensions are  $2.5 \times 30.5 \times 38.1$  cm. The SIO L-Cheapo OBSs have a height of ~0.9 m and a maximum diameter of 97 cm. The anchors are 36-kg iron grates with dimensions  $7 \times 91 \times 91.5$  cm.

Once an OBS is ready to be retrieved, an acoustic release transponder interrogates the instrument at a frequency of 8–11 kHz, and a response is received at a frequency of 11.5–13 kHz. The burn-wire release assembly is then activated, and the instrument is released from the anchor to float to the surface.

### 2.1.2.7 Additional Acoustical Data Acquisition Systems

Along with the airgun operations, two additional acoustical data acquisition systems would be operated from the *Langseth* during the survey, including an MBES and SBP. The ocean floor would be mapped with the Kongsberg EM 122 MBES and a Knudsen Chirp 3260 SBP. These sources are described in § 2.2.3.1 of the PEIS.

## 2.1.3 Monitoring and Mitigation Measures

Standard monitoring and mitigation measures for seismic surveys are described in § 2.4.1.1 and 2.4.2 of the PEIS and are described to occur in two phases: pre-cruise planning and operations. The following sections describe the efforts during both stages for the proposed activity.

### 2.1.3.1 Planning Phase

As discussed in § 2.4.1.1 of the PEIS, mitigation of potential impacts from the proposed activity begins during the planning phase. Several factors were considered during the planning phase of the proposed activity, including

**Energy Source.**—Part of the considerations for the proposed marine seismic survey was to evaluate whether the research objectives could be met with a smaller energy source than the full 36-airgun, 6600-in<sup>3</sup> *Langseth* array, and it was decided that the scientific objectives for the survey could not be met using a smaller source as they would lack the energy and low-frequency content to penetrate deep into the igneous crust.

**Survey Timing.**—The PIs worked with L-DEO and NSF to identify potential times to carry out the survey taking into consideration key factors such as environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and seabirds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using the *Langseth*. Most marine mammal species are expected to occur in the area year-round, although some migratory baleen whales are expected to occur farther south at the time of the survey. Thus, altering the timing of the proposed project likely would result in no net benefits for marine mammals.

**Mitigation Zones.**—During the planning phase, mitigation zones for the proposed marine seismic survey were calculated based on modeling by L-DEO for both the exclusion and the safety zones. Received sound levels have been predicted by L-DEO's model (Diebold et al. 2010, provided as Appendix H in the PEIS), as a function of distance from the airguns, for the 36-airgun array at various tow depths and for a single 1900LL 40-in<sup>3</sup> airgun, which would be used during power downs. This modeling approach uses ray tracing for the direct wave traveling from the array to the receiver and its associated source ghost (reflection at the air-water interface in the vicinity of the array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor). In addition, propagation measurements of pulses from the 36-airgun array at a tow depth of 6 m have been reported in deep water (~1600 m), intermediate water depth on the slope (~600–1100 m), and shallow water (~50 m) in the Gulf of Mexico (GoM) in 2007–2008 (Tolstoy et al. 2009; Diebold et al. 2010).

For deep and intermediate-water cases, the field measurements cannot be used readily to derive mitigation radii, as at those sites the calibration hydrophone was located at a roughly constant depth of 350–500 m, which may not intersect all the sound pressure level (SPL) isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of ~2000 m. Figures 2 and 3 in Appendix H of the PEIS show how the values along the maximum SPL line that connects the points where the isopleths attain their maximum width (providing the maximum distance associated with each sound level) may differ from values obtained along a constant depth line. At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the mitigation model—constructed from the maximum SPL through the entire water column at varying distances from the airgun array—is the most relevant. The results are summarized below.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results for the same array tow depth are in good agreement (Fig. 12 and 14 in Appendix H of the PEIS). Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent (Fig. 11, 12, and 16 in Appendix H of the PEIS). Aside from local topography effects, the region around the critical distance (~5 km in Fig. 11 and 12, and ~4 km in Fig. 16 in Appendix H of the PEIS) is where the observed levels rise closest to the mitigation model curve. However, the observed sound levels are found to fall almost entirely below the mitigation model curve (Fig. 11, 12, and 16 in Appendix H of the PEIS). Thus, analysis of the GoM calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating mitigation radii.

The proposed survey would acquire data in deep water with the 36-airgun array at tow depth of 9 m. For deep water (>1000 m), we use the deep-water radii obtained from L-DEO model results down to a maximum water depth of 2000 m (Fig. 2). The isopleths calculated by the deep-water L-DEO model are essentially a measure of the energy radiated by the source array, where the 150-decibel (dB) Sound Exposure Level (SEL)<sup>2</sup> corresponds to an SPL of ~160 dB<sub>rms</sub>, and 170 SEL corresponds to ~180 dB<sub>rms</sub>.

<sup>2</sup> SEL (measured in dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$ ) is a measure of the received energy in the pulse and represents the SPL that would be measured if the pulse energy were spread evenly across a 1-s period. Because actual seismic pulses are less than 1 s in duration in most situations, this means that the SEL value for a given pulse is usually lower than the SPL calculated for the actual duration of the pulse. In this EA, we assume that rms pressure levels of received seismic pulses would be 10 dB higher than the SEL values predicted by L-DEO's model.

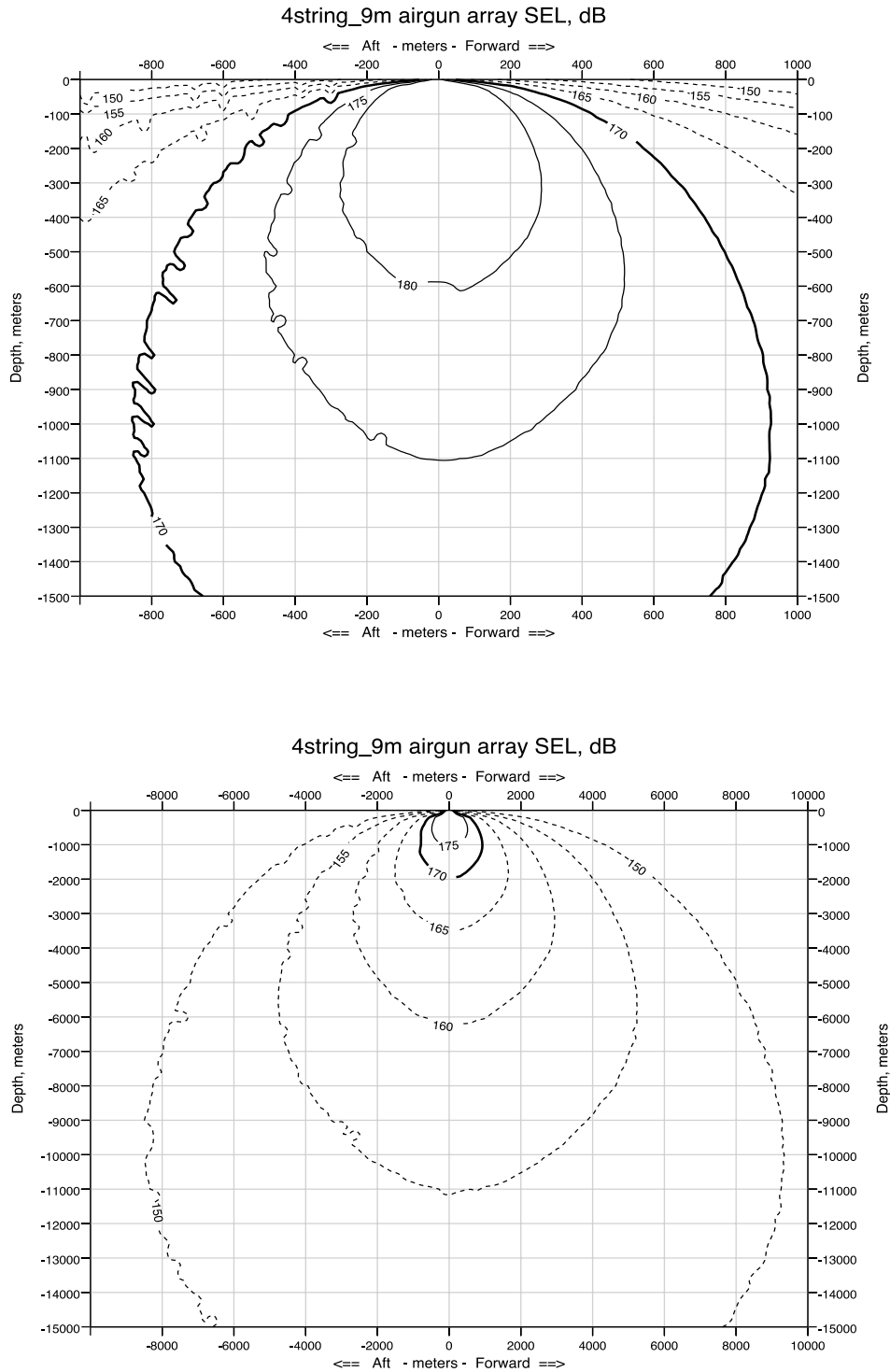


FIGURE 2. Modeled deep-water received sound levels (SELs) from the 36-airgun array planned for use during the proposed survey in the South Atlantic Ocean at a 9-m tow depth. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleth as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.

Measurements have not been reported for the single 40-in<sup>3</sup> airgun. The 40-in<sup>3</sup> airgun fits under the low-energy source category in the PEIS. In § 2.4.2 of the PEIS, Alternative B (the Preferred Alternative) conservatively applies an exclusion zone (EZ) of 100 m for all low-energy acoustic sources in water depths >100 m. This approach is adopted here for the single Bolt 1900LL 40-in<sup>3</sup> airgun that would be used during power downs. L-DEO model results are used to determine the 160-dB<sub>rms</sub> radius for the 40-in<sup>3</sup> airgun at 9-m tow depth in deep water (Fig. 3).

Table 1 shows the 180- and 190-dB re 1  $\mu\text{Pa}_{\text{rms}}$  EZs and 160-dB re 1  $\mu\text{Pa}_{\text{rms}}$  safety zone (distances at which the rms sound levels are expected to be received) for the 36-airgun array and the single (mitigation) airgun. The 180- and 190-dB distances are the safety criteria as specified by NMFS (2000) for cetaceans and pinnipeds, respectively. The 180-dB distance would also be used as the EZ for sea turtles, as required by NMFS in most other recent seismic projects per the Incidental Take Statement (ITS). Enforcement of mitigation zones via power and shut downs would be implemented in the Operational Phase. Southall et al. (2007) made detailed recommendations for new science-based noise exposure criteria. In July 2015, the National Oceanic Atmospheric Administration (NOAA) published a revised version of its 2013 draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2015a), although at the time of preparation of this Draft EA, the date of release of the final guidelines and how they would be implemented are unknown. As such, this Draft EA has been prepared in accordance with the current NOAA acoustic practices, and the procedures are based on best practices noted by Pierson et al. (1998), Weir and Dolman (2007), Nowacek et al. (2013), and Wright (2014).

Enforcement of mitigation zones via power and shut downs would be implemented in the Operational Phase.

#### 2.1.3.2 Operational Phase

Marine mammals and sea turtles are known to occur in the proposed survey area. However, the number of individual animals expected to be approached closely during the proposed activity would be relatively small in relation to regional population sizes. To minimize the likelihood that potential impacts could occur to the species and stocks, monitoring and mitigation measures proposed during the operational phase of the proposed activity, which are consistent with the PEIS and past IHA/ITS requirements, include

1. monitoring by protected species observers (PSOs) for marine mammals, sea turtles, and ESA-listed seabirds diving near the vessel, and observing for potential impacts of acoustic sources on fish;
2. passive acoustic monitoring (PAM);
3. PSO data and documentation; and
4. mitigation during operations (speed or course alteration; power-down, shut-down, and ramp-up procedures; and special mitigation measures for rare species, species concentrations, and sensitive habitats).

Five independently contracted PSOs would be on board the survey vessel with rotating shifts to allow two observers to monitor for marine species during daylight hours, and one observer to conduct PAM during day- and night-time seismic operations. The proposed operational mitigation measures are standard for all high-energy seismic cruises, per the PEIS and are described in the IHA application, and therefore are not discussed further here. Special mitigation measures were considered for this cruise. It is unlikely that concentrations of large whales would be encountered, but if so, they would be avoided.

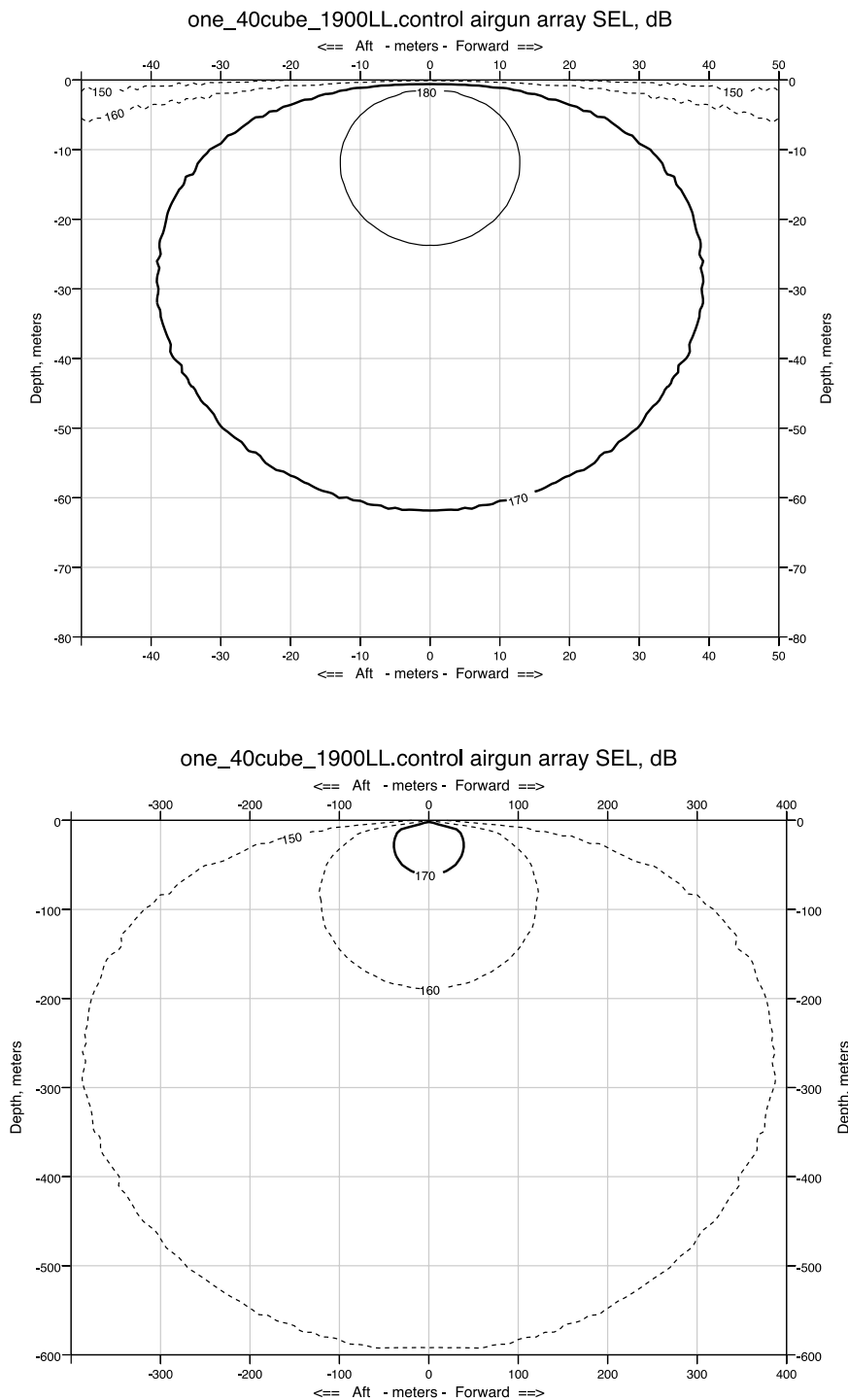


FIGURE 3. Modeled deep-water received sound levels (SELs) from a single 40-in<sup>3</sup> airgun towed at 9 m depth, which is planned for use as a mitigation gun during the proposed survey in the South Atlantic. Received rms levels (SPLs) are expected to be ~10 dB higher. The plot at the top provides the radius to the 170-dB SEL isopleths as a proxy for the 180-dB rms isopleth, and the plot at the bottom provides the radius to the 150-dB SEL isopleth as a proxy for the 160-dB rms isopleth.

TABLE 1. Predicted distances to which sound levels  $\geq 190$ -, 180-, and 160-dB re 1  $\mu\text{Pa}_{\text{rms}}$  are expected to be received during the proposed survey in the South Atlantic Ocean. For the single mitigation airgun, the EZ is the conservative EZ for all low-energy acoustic sources in water depths  $>100$  m defined in the PEIS.

| Source and Volume                              | Tow Depth<br>(m) | Water Depth<br>(m) | Predicted rms Radii (m) |        |        |
|--|------------------|--------------------|-------------------------|--------|--------|
|  |                  |                    | 190 dB                  | 180 dB | 160 dB |
| Single Bolt airgun,<br>40 in <sup>3</sup>      | 9                | $>1000$ m          | 100                     | 100    | 388    |
| 4 strings, 36 airguns,<br>6600 in <sup>3</sup> | 9                | $>1000$ m          | 286                     | 927    | 5780   |

With the proposed monitoring and mitigation provisions, potential effects on most if not all individuals would be expected to be limited to minor behavioral disturbance. Those potential effects would be expected to have negligible impacts both on individual marine mammals and on the associated species and stocks. Ultimately, survey operations would be conducted in accordance with all applicable U.S. federal regulations, including IHA requirements.

## 2.2 Alternative 1: Alternative Survey Timing

An alternative to issuing the IHA for the season requested and to conducting the project then would be to conduct the project during an alternative season, implementing the same monitoring and mitigation measures as under the Proposed Action, and requesting an IHA to be issued for that alternative season. A change in the survey timing to a different season would not affect the ensuing analysis (including take estimates) because the best available species densities for any time of the year have been used. The proposed time for the cruise in austral summer 2016 is the most suitable season logistically for the *Langseth* and the participating scientists. An evaluation of the effects of this Alternative is given in § 4.2.

## 2.3 Alternative 2: No Action Alternative

An alternative to conducting the proposed activity is the “No Action” alternative, i.e., do not issue an IHA and do not conduct the research operations. If the research was not conducted, the “No Action” alternative would result in no disturbance to marine mammals attributable to the proposed activity. Although the No-Action Alternative is not considered a reasonable alternative because it does not meet the purpose and need for the Proposed Action, per Council on Environmental Quality regulations it is included and carried forward for analysis in § 4.3.

## 2.4 Alternatives Considered but Eliminated from Further Analysis

### 2.4.1 Alternative E1: Alternative Location

The goal of the proposed research is to address questions about the evolution of the South Atlantic oceanic crust and the evolution and stability of slow-spreading ridges over time. The survey location and design have been specifically selected to characterize slow-spreading and intermediate-spreading crust in a location where fracture zones are far apart, magnetic lineations are clear, and there is little disruption in seafloor bathymetry. In addition, the location of the proposed survey is linked with potential future IODP drill sites. A location other than the MAR in the South Atlantic would likely not meet the necessary research conditions or research goals. The proposed research underwent the NSF merit review process, and the science, including the site location, was determined to be meritorious.

## 2.4.2 Alternative E2: Use of Alternative Technologies

As described in § 2.6 of the PEIS, alternative technologies to the use of airguns were investigated to conduct high-energy seismic surveys. At this time, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need. Additional details about these technologies are given in the Final USGS EA (RPS 2014a). Table 2 provides a summary of the proposed action, alternatives, and alternatives eliminated from further analysis.

TABLE 2. Summary of Proposed Action, Alternatives Considered, and Alternatives Eliminated

| Proposed Action   | Description   |
|---|---|
| Proposed Action:<br>Conduct a marine geophysical survey and associated activities in the South Atlantic Ocean | Under this action, a 2-D seismic survey is proposed. When considering transit; equipment deployment, maintenance, and retrieval; weather; marine mammal activity; and other contingencies, the proposed activities would be expected to be completed in ~42 days. The affected environment, environmental consequences, and cumulative impacts of the proposed activities are described in § III and IV. The standard monitoring and mitigation measures identified in the NSF PEIS would apply, along with any additional requirements identified by regulating agencies. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies.   |
| Alternatives  | Description   |
| Alternative 1:<br>Alternative Survey Timing   | Under this Alternative, L-DEO would conduct survey operations at a different time of the year. Most odontocetes are likely year-round residents in the survey area, whereas some mysticetes are more likely to occur farther south during austral summer. Altering the timing of the proposed project likely would not result in net benefits. Further, consideration would be needed for constraints for vessel operations and availability of equipment (including the vessel) and personnel. Limitations on scheduling the vessel include the additional research studies planned on the vessel for 2016. The standard monitoring and mitigation measures identified in the NSF PEIS would apply, along with any additional requirements identified by regulating agencies because of the change in timing. All necessary permits and authorizations, including an IHA, would be requested from regulatory bodies. |
| Alternative 2: No Action  | Under this Alternative, no proposed activities would be conducted and seismic data would not be collected. Whereas this alternative would avoid impacts to marine resources, it would not meet the purpose and need for the proposed action. Geological data of scientific value and relevance increasing our understanding of the evolution of the South Atlantic oceanic crust, and the evolution and stability of slow-spreading ridges over time would not be collected. The collection of new data, interpretation of these data, and introduction of new results into the greater scientific community and applicability of these data to other similar settings would not be achieved. No permits and authorizations, including an IHA, would be needed from regulatory bodies, as the proposed action would not be conducted.   |
| Alternatives Eliminated from Further Analysis   | Description   |
| Alternative E1:<br>Alternative Location   | The survey location has been specifically selected to characterize slow- and intermediate-spreading crust in a location where fracture zones are far apart, magnetic lineations are clear, and there is little disruption in seafloor bathymetry. Additionally, the survey would provide useful information for siting potential future IODP drill sites. The proposed science underwent the NSF merit review process, and the science, including the site location, was determined to be meritorious.  |
| Alternative E2: Use of Alternative Technologies   | Under this alternative, L-DEO would use alternative survey techniques, such as marine vibroseis, that could potentially reduce impacts on the marine environment. Alternative technologies were evaluated in the PEIS, § 2.6. At this time, however, these technologies are still not feasible, commercially viable, or appropriate to meet the Purpose and Need.   |

### III AFFECTED ENVIRONMENT

As described in the PEIS, Chapter 3, the description of the affected environment focuses only on those resources potentially subject to impacts. Accordingly, the discussion of the affected environment (and associated analyses) has focused mainly on those related to marine biological resources, as the proposed short-term activity has the potential to impact marine biological resources within the Project area. These resources are identified in § III, and the potential impacts to these resources are discussed in § IV. Initial review and analysis of the proposed Project activity determined that the following resource areas did not require further analysis in this EA:

- *Air Quality/Greenhouse Gases*—Project vessel emissions would result from the proposed activity; however, these short-term emissions would not result in any exceedance of Federal Clean Air standards. Emissions would be expected to have a negligible impact on the air quality within the proposed survey area;

*Land Use*—All activities are proposed to occur in the marine environment. Therefore, no changes to current land uses or activities in the Project area would result from the proposed Project;

- *Safety and Hazardous Materials and Management*—No hazardous materials would be generated or used during the proposed activity. All Project-related wastes would be disposed of in accordance with Federal and international requirements;
- *Geological Resources (Topography, Geology and Soil)*—The proposed Project would result in very minor disturbance to seafloor sediments from OBS deployments; small anchors would not be recovered. The proposed activity would, therefore, not adversely affect geologic resources;
- *Water Resources*—No discharges to the marine environment that would adversely affect marine water quality are expected in the Project area. Therefore, there would be no impacts to water resources resulting from the proposed Project activity;
- *Terrestrial Biological Resources*—All proposed Project activities would occur in the marine environment and would not impact terrestrial biological resources;
- *Visual Resources*—No visual resources would be expected to be negatively impacted as the area of operation is significantly outside of the land and coastal viewshed;
- *Socioeconomic and Environmental Justice*—Implementation of the proposed Project would not affect, beneficially or adversely, socioeconomic resources, environmental justice, or the protection of children. No changes in the population or additional need for housing or schools would occur. Because of the location of the proposed activity and distance from shore, human activities in the area around the survey vessel would be limited to commercial fishing activities and other vessel traffic. Fishing, vessel traffic, and potential impacts are described in further detail in § III and IV. No other socioeconomic impacts would be expected as result of the proposed activity; and
- *Cultural Resources*—There are no known cultural resources in the proposed Project area; therefore, no impacts to cultural resources would be expected.

### 3.1 Physical Environment and Oceanography

The MAR is a continuous underwater mountain range that extends from Iceland (87°N) in the Northern Hemisphere to Bouvet Island (54°S) in the Southern Hemisphere; it divides the Atlantic Ocean into two halves along its north-south axis (Levin and Gooday 2003; Perez et al. 2012). In the South Atlantic, it forms the division between the African and South American plates. The MAR is ~1500 km wide and rises 2000–3000 m above the adjacent abyssal seafloor to ~1000 m below the sea surface (NAS-NRC 1972; Perez et al. 2012). However, the peaks of the MAR extend above sea level in some locations as volcanic oceanic islands, such as Ascension Island, St. Helena, Tristan da Cunha, Gough Island, and Bouvet Island (NAS-NRC 1972; UNESCO-WHC 2015a). The MAR basically comprises a linear, segmented volcano that resulted in the formation of numerous submarine features, including seamounts and hydrothermal vents (Dotinga and Molenaar 2008).

The water around the various seamounts of the MAR is relatively productive compared to the open ocean surrounding them, mainly because of upwelling (Rogers 1994; Probert 1999). The proposed survey is in the South Atlantic Gyral Province as defined by Longhurst (2007). The production rate increases during austral spring, reaching its highest values during October–November before declining during austral summer (Longhurst 2007). In the southwestern Atlantic, the highest levels of primary production were reported from October to December, with a peak production of 2729 mgC/m<sup>2</sup>/day during November (SAUP 2015).

The Atlantic Ocean is further divided into a set of basins which are delimited by secondary transverse ridges (Levin and Gooday 2003). The main transverse ridges in the South Atlantic are the Walvis Ridge in the east and the Rio Grande Rise in the west, which essentially form “bridges” between the central ridge to the African and South American continental margins, respectively (Perez et al. 2012). The Walvis Ridge is several thousand kilometers long, rising from depths >5 km to <1 km (Linden 1980). It extends from southwest to northeast at ~20°–33°S, 5°W–10°E and is located between the continental margin of southwestern Africa and the MAR; it separates the Angola basin from the Cape Basin and consists of a seamount chain (Linden 1980; Perez et al. 2012). The Rio Grande Rise is also composed of seamounts and extends from northwest to southeast at 28°–36°S, 28°–39°W (Perez 2007; Perez et al. 2012). It divides the southwestern Atlantic into two basins, the Argentine Basin to the south and the Brazil Basin to the north (McDowell et al. 1977).

Demersal ocean currents chiefly flow northward in the southwest Atlantic and southward in the southeast Atlantic (Huang and Jin 2002); these currents are largely driven by the seafloor topography and the thermohaline properties of the interacting North Atlantic Deep Water and Antarctic Bottom Water (Perez et al. 2012). Surface and subsurface (to 1500-m depth) currents are dominated by the counterclockwise Subtropical Gyre, consisting of the interconnected Brazil, Antarctic Circumpolar, Benguela, and South Equatorial currents (Perez et al. 2012). The Subtropical Convergence represents the boundary between warm, subtropical surface water to the north and cooler, subantarctic water to the south (Ansorge and Lutjeharms 2007); in the South Atlantic, the Subtropical Convergence lies along ~41.7°S (Llido et al. 2005). The Subantarctic Front is located south of the Subtropical Convergence and marks the boundary between the Polar Frontal Zone to the south and the subantarctic surface water to the north (Ansorge and Lutjeharms 2007). The Antarctic Polar Front or Antarctic Convergence marks the area where northward-moving Antarctic surface water sinks below warmer subantarctic water (Ansorge and Lutjeharms 2007).

### 3.2 Protected Areas

There are numerous marine protected areas (MPAs) in the South Atlantic (e.g., Hoyt 2011). The closest are two World Heritage Site MPAs located >650 km south of the proposed survey area, Gough and Inaccessible islands (Fig. 1; UNESCO-WHC 2015b). The proposed survey area is located within the proposed South Atlantic Whale Sanctuary, a large area extending from the Equator to 40°S (Hoyt 2011). The rationale behind designating this region a sanctuary is to “protect large whales from commercial whaling and to stimulate whale watching for the benefit of local communities, as well as cetacean research and conservation” (Hoyt 2011:p 245). Protection would extend to 53 species of cetaceans, notably including southern right, pygmy right, and humpback whales (Hoyt 2011). However, the proposal to establish a sanctuary in the South Atlantic has been rejected repeatedly by the International Whaling Commission (IWC 2015a).

The majority of the proposed survey area is situated within the South East Atlantic Fisheries Organization (SEAFO) Convention Area, one of four regional fisheries management areas in the Atlantic Ocean. The SEAFO Convention Area encompasses all waters outside of areas of national jurisdiction in the southeast Atlantic Ocean, an irregular area extending from the Equator to 50°S and from 20°W to 30°E (Bensch et al. 2009; see SEAFO 2014a). SEAFO is committed to “ensuring the long-term conservation and sustainable use of all living marine resources in the South East Atlantic Ocean, and to safeguarding the environment and marine ecosystems in which the resources occur” (SEAFO 2014b). There is currently no equivalent organization for the waters of the southwest Atlantic Ocean.

The eastern portion of the proposed survey area intersects with a SEAFO Vulnerable Marine Ecosystem (VME) Closed Area (Fig. 1), Unnamed Number 15 (SEAFO 2015). VME Closed Areas are closed to bottom contact fishing gear and serve to protect “seamounts and vulnerable marine habitats from significant adverse impacts caused by fishing” (SEAFO 2014c). SEAFO includes in its protection protocols the scientific monitoring of several benthic invertebrate VME indicator species/groups, including sponges, gorgonian corals, hydrocorals, stony corals, black corals, zoanthids, soft corals, sea pens, erect bryozoans, sea lilies, basket stars, annelids, and sea squirts (SEAFO 2014c). There are two additional VME Closed Areas in the general vicinity of the proposed survey area (Fig. 1), Wüst Seamount and Unnamed Number 18 (SEAFO 2015), located >500 km southeast and >1000 km south of the proposed survey area, respectively.

### 3.3 Marine Mammals

Forty species of cetaceans (9 mysticetes and 31 odontocetes) and 2 pinniped species could potentially occur in the offshore waters of the proposed survey area in the South Atlantic Ocean. Six of the 42 marine mammal species are listed under the U.S. ESA as **Endangered**: the southern right, humpback, fin, sei, blue, and sperm whales. General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of marine mammals is given in § 3.6.1, § 3.7.1, and § 3.8.1 of the PEIS. The general distributions of marine mammals in the southwestern Atlantic Ocean are discussed in the PEIS in § 3.6.3.3 for mysticetes, § 3.7.3.3 for odontocetes, and § 3.8.3.3 for pinnipeds. The rest of this section deals with species distribution in the proposed offshore survey area across the MAR in the South Atlantic Ocean.

Information on the occurrence near the proposed survey area, habitat, population size, and conservation status for each of the 42 marine mammal species is presented in Table 3. Although an additional 20 species of marine mammals are known to occur in the South Atlantic Ocean, they are unlikely to occur within the proposed survey area because they have more coastal distributions in the

South Atlantic (e.g., spectacled porpoise *Phocoena dioptrica*, Burmeister's porpoise *Phocoena*

TABLE 3. The habitat, occurrence, regional population sizes, and conservation status of marine mammals that could occur in or near the proposed survey area in the South Atlantic Ocean.

| Species                      | Occurrence | Habitat                 | Population Size                                     | ESA <sup>1</sup> | IUCN <sup>2</sup> | CITES <sup>3</sup> |
|------------------------------|------------|-------------------------|---|------------------|-------------------|--------------------|
| <b>Mysticetes</b>            |            |                         |   |                  |                   |                    |
| Southern right whale         | Rare       | Coastal, shelf          | 12,000 <sup>4</sup>                                 | EN               | LC                | I                  |
| Pygmy right whale            | Rare       | Coastal, pelagic        | N.A.  | NL               | DD                | I                  |
| Humpback whale               | Rare       | Coastal, shelf, pelagic | 42,000 <sup>4</sup>                                 | EN <sup>5</sup>  | LC                | I                  |
| Common (dwarf) minke whale   | Rare       | Shelf, pelagic          | 515,000 <sup>4,6</sup>                              | NL               | LC                | I                  |
| Antarctic minke whale        | Rare       | Shelf, pelagic          | 515,000 <sup>4,6</sup>                              | NL               | DD                | I                  |
| Bryde's whale                | Rare       | Coastal, pelagic        | 48,109 <sup>7</sup>                                 | NL               | DD                | I                  |
| Sei whale                    | Uncommon   | Shelf edges, pelagic    | 10,000 <sup>8</sup>                                 | EN               | EN                | I                  |
| Fin whale                    | Uncommon   | Coastal, pelagic        | 15,000 <sup>8</sup>                                 | EN               | EN                | I                  |
| Blue whale                   | Rare       | Coastal, shelf, pelagic | 2300 true <sup>4</sup> ;<br>1500 pygmy <sup>8</sup> | EN               | EN                | I                  |
| <b>Odontocetes</b>           |            |                         |   |                  |                   |                    |
| Sperm whale                  | Uncommon   | Slope, pelagic          | 10,500 <sup>9</sup>                                 | EN               | VU                | I                  |
| Dwarf sperm whale            | Rare       | Shelf, slope, pelagic   | N.A.  | NL               | DD                | II                 |
| Pygmy sperm whale            | Rare       | Shelf, slope, pelagic   | N.A.  | NL               | DD                | II                 |
| Cuvier's beaked whale        | Uncommon   | Slope                   | 599,300 <sup>10</sup>                               | NL               | LC                | II                 |
| Arnoux's beaked whale        | Rare       | Pelagic                 | 599,300 <sup>10</sup>                               | NL               | DD                | I                  |
| Shepherd's beaked whale      | Rare       | Pelagic                 | N.A.  | NL               | DD                | II                 |
| Southern bottlenose whale    | Rare       | Pelagic                 | 599,300 <sup>10</sup>                               | NL               | LC                | I                  |
| Hector's beaked whale        | Rare       | Pelagic                 | N.A.  | NL               | DD                | II                 |
| True's beaked whale          | Rare       | Pelagic                 | N.A.  | NL               | DD                | II                 |
| Gervais' beaked whale        | Rare       | Pelagic                 | N.A.  | NL               | DD                | II                 |
| Gray's beaked whale          | Rare       | Pelagic                 | 599,300 <sup>10</sup>                               | NL               | DD                | II                 |
| Andrew's beaked whale        | Rare       | Pelagic                 | N.A.  | NL               | DD                | II                 |
| Strap-toothed beaked whale   | Rare       | Pelagic                 | 599,300 <sup>10</sup>                               | NL               | DD                | II                 |
| Blainville's beaked whale    | Rare       | Slope, pelagic          | N.A.  | NL               | DD                | II                 |
| Spade-toothed beaked whale   | Rare       | Pelagic                 | N.A.  | NL               | DD                | II                 |
| Rough-toothed dolphin        | Uncommon   | Shelf, pelagic          | N.A.  | NL               | LC                | II                 |
| Common bottlenose dolphin    | Uncommon   | Coastal, pelagic        | 600,000 <sup>11</sup>                               | NL               | LC                | II                 |
| Pantropical spotted dolphin  | Uncommon   | Coastal, slope, pelagic | N.A.  | NL               | LC                | II                 |
| Spinner dolphin              | Rare       | Coastal, pelagic        | N.A.  | NL               | DD                | II                 |
| Clymene dolphin              | Rare       | Pelagic                 | N.A.  | NL               | DD                | II                 |
| Striped dolphin              | Rare       | Mainly pelagic          | N.A.  | NL               | LC                | II                 |
| Fraser's dolphin             | Uncommon   | Pelagic                 | N.A.  | NL               | LC                | II                 |
| Short-beaked common dolphin  | Uncommon   | Coastal, pelagic        | N.A.  | NL               | LC                | II                 |
| Hourglass dolphin            | Rare       | Pelagic                 | 150,000 <sup>8</sup>                                | NL               | LC                | II                 |
| Southern right whale dolphin | Uncommon   | Pelagic                 | N.A.  | NL               | DD                | II                 |
| Melon-headed whale           | Rare       | Pelagic                 | N.A.  | NL               | LC                | II                 |
| Pygmy killer whale           | Uncommon   | Pelagic                 | N.A.  | NL               | DD                | II                 |
| False killer whale           | Rare       | Pelagic                 | N.A.  | NL               | DD                | II                 |
| Killer whale                 | Rare       | Coastal, pelagic        | 25,000 <sup>12</sup>                                | NL               | DD                | II                 |
| Long-finned pilot whale      | Uncommon   | Shelf, slope, pelagic   | 200,000 <sup>8</sup>                                | NL               | DD                | II                 |
| Short-finned pilot whale     | Uncommon   | Pelagic                 | N.A.  | NL               | DD                | II                 |
| <b>Pinnipeds</b>             |            |                         |   |                  |                   |                    |
| Subantarctic fur seal        | Rare       | Coastal, pelagic        | >310,000 <sup>13</sup>                              | NL               | LC                | II                 |
| Southern elephant seal       | Rare       | Coastal, pelagic        | 640,000 <sup>14</sup>                               | NL               | LC                | II                 |

N.A. = Data not available

<sup>1</sup> U.S. Endangered Species Act (NMFS 2015a): EN = Endangered; NL = Not Listed<sup>2</sup> Classification from the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN 2015): EN = Endangered; VU = Vulnerable; LC = Least Concern; DD = Data Deficient<sup>3</sup> Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2015): Appendix I = Threatened with extinction; Appendix II = not necessarily now threatened with extinction but may become so unless trade is closely controlled<sup>4</sup> Southern Hemisphere (IWC 2015b)<sup>5</sup> NMFS has recently (April 2015) proposed that 14 distinct population segments (DPSs) of humpback whales should be recognized and that 10 of those should be delisted, including the Brazil and Gabon/Southwest Africa DPSs (NMFS 2015b).

<sup>6</sup> Dwarf and Antarctic minke whales combined<sup>7</sup> Southern Hemisphere (IWC 1981)<sup>8</sup> Antarctic (Boyd 2002)<sup>9</sup> Estimate for the Antarctic, south of 60°S (Whitehead 2002)<sup>10</sup> All beaked whales south of the Antarctic Convergence; mostly southern bottlenose whales (Kasamatsu and Joyce 1995)<sup>11</sup> Worldwide estimate (Wells and Scott 2009)<sup>12</sup> Minimum estimate for Southern Ocean (Ford 2009)<sup>13</sup> Total world population (Arnould 2009)<sup>14</sup> Total world population (Hindell and Perrin 2009)

*spinipinnis*, Franciscana *Pontoporia blainvillei*, Guiana dolphin *Sotalia guianensis*, Atlantic humpback dolphin *Sousa teuszii*, Peale's dolphin *Lagenorhynchus australis*, Commerson's dolphin *Cephalorhynchus commersonii*, Heaviside's dolphin *Cephalorhynchus heavisidii*, long-beaked common dolphin *Delphinus capensis*, Atlantic spotted dolphin *Stenella frontalis*, dusky dolphin *Lagenorhynchus obscurus*, Risso's dolphin *Grampus griseus*, South American sea lion *Otaria flavescens*, South American fur seal *Arctocephalus australis*, and South African fur seal *Arctocephalus pusillus*), or their distributional range is farther south (e.g., leopard seal *Hydrurga leptonyx*, crabeater seal *Lobodon carcinophaga*, Ross seal *Ommatophoca rossii*, Weddell seal *Leptonychotes weddellii*, and Antarctic fur seal *Arctocephalus gazella*). Although extralimital records of a leopard seal and several Antarctic fur seals exist for Gough Island (Wilson et al. 2006), none of the aforementioned species are discussed further here.

### 3.3.1 Mysticetes

#### 3.3.1.1 Southern Right Whale (*Eubalaena australis*)

The southern right whale occurs throughout the Southern Hemisphere between ~20°S and 60°S (Kenney 2009), although in areas where cold water currents extend northwards, it may occur farther north (Best 2007). It migrates between summer foraging areas at high latitudes and winter breeding/calving areas in low latitudes (Kenney 2009). However, migration routes from foraging areas to nursery and feeding grounds are not well known (Best et al. 1993).

Based on available data, the current distributional range of southern right whales in the South Atlantic Ocean does not appear to extend as far north as the proposed survey area; however, survey effort in pelagic waters of this region has been limited (Kenney 2009). In the South Atlantic, breeding areas are known to occur or have occurred historically in the shallow coastal waters of South America, including Argentina and Brazil, as well as the Falkland Islands, Tristan de Cunha, Namibia, and South Africa (IWC 2001). Right whales occurring in breeding and nursing grounds of southern Brazil and the Península Valdés, Argentina, possibly comprise two separate subpopulations that exploit different habitats; feeding also occurs at these grounds (Vighi et al. 2014). Waters south of South Africa are believed to be a nursery area, as females and calves are sighted there, whereas waters off western South Africa might currently be used as a year-round feeding area (Barendse and Best 2014). The highest sighting rates off western South Africa occur during early austral summer, and the lowest rates have been reported from autumn to mid winter (Barendse and Best 2014).

Although southern right whale calving/breeding areas are located in nearshore waters, feeding grounds in the Southern Ocean apparently are located mostly in pelagic waters (Kenney 2009). Travel by right whales from the coasts of South America and Africa to the waters of the mid-Atlantic have been documented (Best et al. 1993; Rowntree et al. 2001; Mate et al. 2011). Based on photo-identification work, right whales were reported to have traveled between Gough Island and South Africa, and from Argentina to Tristan da Cunha (Best et al. 1993). Adult right whales at Gough Island were sighted on 10 September 1983, and two adult whales and a calf were observed at Tristan da Cunha on 14 October

1989 (Best et al. 1993). Six right whale sightings were also made in Tristan waters from August to October 1971 (Best and Roscoe 1974). Right whales were also documented to travel from feeding areas off Argentina to South Georgia (Best et al. 1993) and Shag Rocks (Moore et al. 1999). Thus, there is potential for mixing of populations between calving grounds on either side of the South Atlantic Ocean, and at foraging areas near South Georgia (Best et al. 1993; Best 2007; Patenaude et al. 2007).

In September 2001, 21 right whales were equipped with radio tags in South Africa (Mate et al. 2011). Five of them migrated southward to waters southeast of Gough Island, Bouvet Island, and beyond (Mate et al. 2011). Four satellite-tagged whales traveled into St. Helena Bay on the west coast of South Africa; this might be a feeding area (Mate et al. 2011). Other tagged whales moved southward and appeared to remain near the Subtropical Convergence and Antarctic Polar Front, presumably to feed (Mate et al. 2011). In the first two weeks after five southern right whales were tagged during October–November 2014 at nursery grounds off Península Valdés, Argentina, three young males moved southeastward into offshore waters, and two females with calves remained close to the coast (IWC 2014). Subsequently, one young male moved towards the Sandwich Islands, the other two young males were reported in shelf waters off Argentina, and one female with a calf moved northeastward off the shelf (EVOTIS 2015).

Best et al. (2009) also reported southern right whale sightings and catches in the Tristan da Cunha archipelago. From 1983 to 1991, 75 sightings totaling 116 right whales were observed during aerial surveys of Tristan waters (Best et al. 2009). One sighting was made off Inaccessible Island; all others were made at Tristan Island (Best et al. 2009). The majority of sightings occurred during September–October, but sightings were also made during April, June–August, and November–December (Best et al. 2009). This region is likely an oceanic nursing area for the right whale (Best et al. 2009). Additionally, a single southern right whale has been reported for waters near St. Helena (Clingham et al. 2013).

Historically, right whale catches were made between 30 and 40°S, from the coast of Africa to the coast of South America; most catches were made from October to January at whaling grounds including the Tristan and Pigeon grounds, and False and Brazil banks (Townsend 1935 *in* Best et al. 1993; Best et al. 2009). Right whale catches were also made at the Tristan da Cunha archipelago from 1951 to 1971 by Soviet fleets (Tormosov et al. 1998). There are ~3800 records of southern right whales for the South Atlantic in the Ocean Biogeographic Information System (OBIS) database, including nearshore and offshore waters (OBIS 2015). Most records (2511) are from historical catch data; 20 catches occurred near the proposed survey area, at 30–32°S, 12–28°W (Townsend 1931, 1935 *in* OBIS 2015).

High mortalities in southern right whales calves have been documented at Península Valdés since 2003 (Rowntree et al. 2013). During 2003–2011, a total of 482 right whale mortalities have been reported, 89% of which were calves; in 2012, 116 whales were found stranded (Rowntree et al. 2013). To date, at least 672 southern right whales have died at Península Valdés (IWC 2014). It is uncertain at this time what is causing these high mortality rates, but disease, nutritional stress, biotoxins, contaminants, and/or gull harassment could be explanatory variables (Rowntree et al. 2013).

### 3.3.1.2 Pygmy Right Whale (*Caperea marginata*)

The distribution of the pygmy right whale is circumpolar in the Southern Hemisphere between 30°S and 55°S in oceanic and coastal environments (Jefferson et al. 2008; Kemper 2009). The pygmy right whale appears to be non-migratory, although there may be some movement inshore in spring and summer (Kemper 2002; Jefferson et al. 2008). Foraging areas are not known, but it seems likely that

pygmy right whales may feed at productive areas in higher latitudes, such as near the Subtropical Convergence (Best 2007).

In the South Atlantic, pygmy right whale records exist for southern Africa, South America, the Falkland Islands, and pelagic waters (Baker 1985). Bester and Ryan (2007) suggested that pygmy right whales occur in the Tristan da Cunha archipelago. One was taken by whalers at 35°S and 8°W on 30 November 1970 (Budylenko et al. 1973 in Best et al. 2009). The waters of the proposed survey area are considered part of the pygmy right whale's secondary range (Jefferson et al. 2008). There are no OBIS records of pygmy right whales for the offshore waters of the proposed survey area, but 10 records exist off southwestern Africa (OBIS 2015).

### 3.3.1.3 Humpback Whale (*Megaptera novaeangliae*)

The humpback whale is found in all ocean basins (Clapham 2009). Based on recent genetic data, there could be three subspecies, occurring in the North Pacific, North Atlantic, and Southern Hemisphere (Jackson et al. 2014). The humpback whale is highly migratory, traveling between mid- to high-latitude waters where it feeds during spring to fall and low-latitude wintering grounds over shallow banks, where it calves (Winn and Reichley 1985). Although considered to be mainly a coastal species, it often traverses deep pelagic areas while migrating (Baker et al. 1998; Garrigue et al. 2002; Zerbini et al. 2011).

In the Southern Hemisphere, humpback whales migrate annually from summer foraging areas in the Antarctic to breeding grounds in tropical seas (Clapham 2009). The International Whaling Commission (IWC) recognizes seven breeding populations in the Southern Hemisphere that are linked to six foraging areas in the Antarctic (Clapham 2009). Two of the breeding grounds are in the South Atlantic: one off Brazil and another off West Africa (Engel and Martin 2009). Bettridge et al. (2015) have identified humpback whales at these breeding locations as the Brazil and Gabon/Southwest Africa DPSs.

Breeding stock 'A' consists of whales that occur between ~5°S and 23°S in the coastal waters off Brazil; this population was estimated at 6404 individuals (e.g., Andriolo et al. 2010). It appears to be most abundant at Abrolhos Bank, which is the main breeding area for the humpback in the western South Atlantic (e.g., Martins et al. 2001; Andriolo et al. 2006, 2010). Humpbacks start aggregating in this area in June, and most have migrated southward by November (Engel and Martin 2009), although some depart as late as December (Zerbini et al. 2011). Whales migrating southward from Brazil have been shown to traverse offshore, pelagic waters within a narrow migration corridor (Zerbini et al. 2006, 2011) en route to feeding areas along the Scotia Sea, including the waters around Shag Rocks, South Georgia, and the South Sandwich Islands (Stevick et al. 2006; Zerbini et al. 2006, 2011; Engel et al. 2008; Engel and Martin 2009).

The southeastern Atlantic breeding stock 'B' occurs off western Africa (Rosenbaum et al. 2009; Carvalho et al. 2011). There may be two breeding substocks in this area, including individuals in the main breeding area in the Gulf of Guinea and those animals migrating past South Africa (Carvalho et al. 2011). In addition, wintering humpbacks have also been reported on the continental shelf of northwest Africa, which may represent the northernmost humpback whales that are known to winter in the Gulf of Guinea (Van Waerebeek et al. 2013). The west coast of South Africa might not be a 'typical' migration corridor, as humpbacks are also known to feed in the area; they are known to occur in the region during the northward migration (July–August), the southward migration (October–November), and into February (Barendse et al. 2010; Carvalho et al. 2011). The highest sighting rates in the area occurred during mid spring through summer (Barendse et al. 2010).

Humpbacks have been seen on breeding grounds around São Tomé in the Gulf of Guinea from August through November; off Gabon, whales occur from late June to December (Carvalho et al. 2011). Feeding areas for this stock include Bouvet Island (Rosenbaum et al. 2014) and waters of the Antarctic Peninsula (Barendse et al. 2010). Based on whales that were satellite-tagged in Gabon in winter 2002, migration routes southward include offshore waters along Walvis Ridge (Rosenbaum et al. 2014). Migration rates were relatively high between populations within the southeastern Atlantic (Rosenbaum et al. 2009). Genetic studies also showed evidence of migration between the southwestern and southeastern Atlantic stocks (Rosenbaum et al. 2009). In fact, similarities in humpback whale songs have been demonstrated between Brazil and Gabon (Darling and Sousa-Lima 2005). Genetic data also showed relatively high effective migration rates between western and eastern Africa (Rosenbaum et al. 2009). Based on photo-identification work, one female humpback whale traveled from Brazil to Madagascar, a distance of >9800 km (Stevick et al. 2011). Deoxyribonucleic acid (DNA) sampling showed evidence of a male humpback having traveled from western Africa to Madagascar (Pomilla and Rosenbaum 2005).

Humpbacks occur occasionally around the Tristan da Cunha archipelago (Bester and Ryan 2007). Three records exist for Tristan waters, all south of 37°S (Best et al. 2009). Humpback whales have also been sighted off St. Helena (MacLeod and Bennett 2007; Clingham et al. 2013). Numerous humpbacks were detected visually and acoustically during a survey off Brazil from Vitória at ~20°S, 40°W, to Trindade and Martim Vaz islands during August–September 2010 (Wedekin et al. 2014). One adult humpback was seen on 31 August near Trindade Island, at 20.5°S, 29.3°W in a water depth of 150 m, but no acoustic detections were made east of 35°W (Wedekin et al. 2014). Numerous sightings were also made near Trindade Island during July–August 2007 and before that date (Siciliano et al. 2012).

The waters of the proposed survey area are considered part of the humpback's secondary range (Jefferson et al. 2008). For the South Atlantic, the OBIS database shows numerous sightings along the coasts of South America and Africa, at least 9 records for areas >1000 km offshore, and two records near the proposed survey area (OBIS 2015). Two sightings were made at 30.8°S, 17.2°W during August and October of 1910 during the British Antarctic Expedition; the next nearest sighting was reported at 25.1°S, 25.8°W, ~900 km north of the survey line (Southwestern Pacific OBIS 2014).

#### **3.3.1.4 Common Minke Whale (*Balaenoptera acutorostrata*)**

The common minke whale has a cosmopolitan distribution ranging from the tropics and sub-tropics to the ice edge in both hemispheres (Jefferson et al. 2008). A smaller form (unnamed subspecies) of the common minke whale, known as the dwarf minke whale, occurs in the Southern Hemisphere, where its distribution overlaps with that of the Antarctic minke whale (*B. bonaerensis*) during summer (Perrin and Brownell 2009). The dwarf minke whale is generally found in shallower coastal waters and over the shelf in regions where it overlaps with *B. bonaerensis* (Perrin and Brownell 2009). The range of the dwarf minke whale is thought to extend as far south as 65°S (Jefferson et al. 2008) and as far north as 2°S in the Atlantic off South America, where it can be found nearly year-round (Perrin and Brownell 2009). It is known to occur off South Africa during autumn and winter (Perrin and Brownell 2009) and likely occurs in the waters of the Tristan da Cunha archipelago (Bester and Ryan 2007).

The waters of the proposed survey area are considered to be within the possible range of the common (dwarf) minke whale, with the primary range occurring in nearshore and offshore waters of South America and along the coast of southwestern Africa (Jefferson et al. 2008). There are no OBIS records of common minke whales for the offshore waters of the proposed survey area, but 30 records exist for nearshore waters of the South Atlantic along the coasts of South America and Africa (OBIS 2015).

### 3.3.1.5 Antarctic Minke Whale (*Balaenoptera bonaerensis*)

The Antarctic minke whale has a circumpolar distribution in coastal and offshore areas of the Southern Hemisphere from ~7°S to the ice edge (Jefferson et al. 2008). It is found between 60°S and the ice edge during the austral summer; in the austral winter, it is mainly found at mid-latitude breeding grounds, including off western South Africa and northeastern Brazil, where it is primarily oceanic, occurring beyond the shelf break (Perrin and Brownell 2009).

Antarctic minke whales are also likely to occur in the Tristan da Cunha archipelago (Bester and Ryan 2007). Two groups totaling seven whales were sighted at 36.4°S, 8.5°W on 7 October 1988 (Best et al. 2009). A sighting of two Antarctic minke whales was made off Brazil during an August–September 2010 survey from Vitória, at ~20°S, 40°W, to Trindade and Martim Vaz islands; the whales were seen in association with a group of rough-toothed dolphins near 19.1°S, 35.1°W on 21 August (Wedekin et al. 2014). There are no OBIS records of Antarctic minke whales for the offshore waters of the proposed survey area, but three records exist for nearshore waters of the South Atlantic along the coasts of South America and Africa (OBIS 2015).

### 3.3.1.6 Bryde's Whale (*Balaenoptera edeni/brydei*)

Bryde's whale occurs in all tropical and warm temperate waters in the Pacific, Atlantic, and Indian oceans, between 40°N and 40°S (Kato and Perrin 2009). It is one of the least known large baleen whales, and it remains uncertain how many species are represented in this complex (Kato and Perrin 2009). *B. brydei* is commonly used to refer to the larger form or “true” Bryde's whale and *B. edeni* to the smaller form; however, some authors apply the name *B. edeni* to both forms (Kato and Perrin 2009; Rudolph and Smeenk 2009). The smaller form is restricted to coastal waters (Rudolph and Smeenk 2009). Bryde's whale remains in warm (>16°C) water year-round, and seasonal movements have been recorded towards the Equator in winter and offshore in summer (Kato and Perrin 2009). It is frequently observed in biologically productive areas such as continental shelf breaks (Davis et al. 2002) and regions subjected to coastal upwelling (Gallardo et al. 1983; Siciliano et al. 2004).

In the South Atlantic, Bryde's whale is known to occur in the waters off Brazil (e.g., Siciliano et al. 2004) and southern Africa (e.g., Best 2001). Three populations of Bryde's whales have been proposed for the waters off southern Africa, including the South African Inshore Stock, the pelagic Southeast Atlantic Stock, and the Southwest Indian Ocean Stock, which is restricted to the Indian Ocean (Best 2001). The pelagic waters of the Atlantic Ocean are considered part of the Bryde's whale's secondary range (Jefferson et al. 2008). A Bryde's whale was sighted in the offshore waters of the South Atlantic during a cruise from Spain to South Africa in November 2009, near 22°S, 6°W (Shirshov Institut n.d.), >1000 km from the proposed survey area. In the OBIS database, there are no records for the offshore waters of the proposed survey area, but there are 12 records at the Iziko South African Museum (OBIS 2015).

### 3.3.1.7 Sei Whale (*Balaenoptera borealis*)

The sei whale occurs in all ocean basins (Horwood 2009). It undertakes seasonal migrations to feed in sub-polar latitudes during summer, returning to lower latitudes during winter to calve (Horwood 2009). In the Southern Hemisphere, sei whales typically concentrate between the Subtropical and Antarctic convergences during the summer (Horwood 2009).

Twenty sightings of sei whales were made in the coastal waters of Argentina and in the Falkland Islands from 2004 to 2008, with the majority of sightings during August–September (Iñíguez et al. 2010). A group of 2–4 sei whales was seen near St. Helena during April 2011 (Clingham et al. 2013). Although

the occurrence of sei whales is likely in the Tristan da Cunha archipelago (Bester and Ryan 2007), there have been no recent records of sei whales in the region; however, sei whale catches were made here in the 1960s (Best et al. 2009). Sei whales were also taken off southern Africa during the 1960s, with some catches reported just to the southeast of the proposed survey area; catches were made during the May–July northward migration as well as during the August–October southward migration (Best and Lockyer 2002).

There is one sei whale record in the OBIS database near the proposed survey area, and two additional records for waters to the east of the proposed survey area (OBIS 2015). The sighting near the proposed survey area was made at 30.8°S and 17.2°W in August 1910 during the British Antarctic Expedition; the next nearest sighting was reported for 33.3°S and 8.0°W, ~900 km north of the survey line (Southwestern Pacific OBIS 2014). One more sighting was reported for 35.1°S and 6.4°W by the United Kingdom (U.K.) Royal Navy (Maughan 2003).

### 3.3.1.8 Fin Whale (*Balaenoptera physalus*)

The fin whale is widely distributed in all the world's oceans (Gambell 1985), although it is most abundant in temperate and cold waters (Aguilar 2009). Nonetheless, its overall range and distribution is not well known (Jefferson et al. 2008). Fin whales most commonly occur offshore, but can also be found in coastal areas (Aguilar 2009). Most populations migrate seasonally between temperate waters where mating and calving occur in winter, and polar waters where feeding occurs in the summer; they are known to use the shelf edge as a migration route (Evans 1987). Sergeant (1977) suggested that fin whales tend to follow steep slope contours, either because they detect them readily, or because the contours are areas of high biological productivity. However, fin whale movements have been reported to be complex, and not all populations follow this simple pattern (Jefferson et al. 2008).

In the Southern Hemisphere, fin whales are typically distributed south of 50°S in the austral summer, and they migrate northward to breed in the winter (Gambell 1985). Fin whales appear to be somewhat common in the Tristan da Cunha archipelago from October to December (Bester and Ryan 2007). Historical whaling data also show several catches for this area (Best et al. 2009) and off southern Africa (Best 2007). Several sightings were made off western South Africa during November 2009; one sighting was reported near 30°S and 2°E, and several other sightings were made near 35°S and 11°E (Shirshov Institute n.d.). Forty fin whales were seen during a transatlantic voyage along 20°S during August 1943 between 5° and 25°W (Wheeler 1946 in Best 2007).

A group of two fin whales was sighted during an August–September 2010 survey off Brazil from Vitória at ~20°S, 40°W to Trindade and Martim Vaz islands; the group was seen at Trindade Island, near 20.5°S, 29.3°W, on 31 August (Wedekin et al. 2014). There are no OBIS records of fin whales for the offshore waters of the proposed survey area, but 15 records exist in the South Atlantic for the nearshore waters along the coasts of South America and Africa (OBIS 2015).

### 3.3.1.9 Blue Whale (*Balaenoptera musculus*)

The blue whale has a cosmopolitan distribution, but tends to be mostly pelagic, only occurring nearshore to feed and possibly breed (Jefferson et al. 2008). *B.m. intermedia* (the true blue whale) occurs in the Antarctic and *B.m. brevicauda* (the pygmy blue whale) inhabits the sub-Antarctic zone (Sears and Perrin 2009). However, it is uncertain whether the pygmy whale occurs in the South Atlantic Ocean; no confirmed sightings or acoustic detections have been made in this region (Branch et al. 2007). The

Antarctic blue whale is typically found south of 55°S during summer, although some are known not to migrate (Branch et al. 2007).

An extensive data review and analysis by Branch et al. (2007) showed that blue whales are essentially absent from the central regions of major ocean basins, including the South Atlantic. No sightings or catches were made near the proposed survey area, although a handful of blue whales were landed off the coasts of South America and Africa; most catches occurred in the waters of the Southern Ocean during January–March (Branch et al. 2007). In addition, there are very few reports of blue whales for the southwest Atlantic, only scattered records for Brazil, Uruguay, and Argentina (Branch et al. 2007). Similarly, there have only been only two sighting records off southwestern Africa and no strandings since 1973, even though large catches occurred there (Branch et al. 2007). It is possible that this population was almost extirpated by whaling (Branch et al. 2007).

For the South Atlantic, there are two records in the OBIS database of blue whale sightings in offshore waters and two records off the coast of Argentina (OBIS 2015). One offshore sighting was made at 13.4°S, 26.8°W and the other at 15.9°S, 4.6°W (Maughan 2003; Branch et al. 2007). The occurrence of blue whales in the Tristan da Cunha archipelago also seems likely (Bester and Ryan 2007). At least one sighting has been made to the southeast of the region (Branch et al. 2007).

### 3.3.2 Odontocetes

#### 3.3.2.1 Sperm Whale (*Physeter macrocephalus*)

The sperm whale is widely distributed, occurring from the edge of the polar pack ice to the Equator in both hemispheres (Whitehead 2009). In general, it is distributed over large temperate and tropical areas that have high secondary productivity and steep underwater topography, such as volcanic islands (Jaquet and Whitehead 1996). Its distribution and relative abundance can vary in response to prey availability, most notably squid (Jaquet and Gendron 2002).

The closest sperm whale sighting to the proposed survey area was at 30.1°S, 14.3°E (Clingham et al. 2013). Bester and Ryan (2007) reported that sperm whales might be common in the Tristan da Cunha archipelago. Catches of sperm whales in the 19<sup>th</sup> century were made in Tristan waters between October and January (Townsend 1935 in Best et al. 2009), and catches also occurred there in the 1960s (Best et al. 2009). One group was seen at St. Helena during July 2009 (Clingham et al. 2013). Whaling data from the South Atlantic indicate that sperm whales may be migratory off South Africa, with peak abundances reported in the region during autumn and late winter/spring (Best 2007).

There are ~3080 records of sperm whales for the South Atlantic in the OBIS database, including nearshore waters of South American and Africa and offshore waters (OBIS 2015). Most (3069) records are from historical catch data; ~11 catches occurred near the proposed survey area, between 30–32°S and 12–28°W (Townsend 1931, 1935 in OBIS 2015).

#### 3.3.2.2 Dwarf (*Kogia sima*) and Pygmy (*K. breviceps*) Sperm Whales

Dwarf and pygmy sperm whales are distributed widely throughout tropical and temperate seas, but their precise distributions are unknown because much of what we know of the species comes from strandings (McAlpine 2009). They are difficult to sight at sea, because of their dive behavior and perhaps because of their avoidance reactions to ships and behavior changes in relation to survey aircraft (Würsig et al. 1998). The two species are often difficult to distinguish from one another when sighted (McAlpine 2009).

Both *Kogia* species are sighted primarily along the continental shelf edge and slope and over deeper waters off the shelf (Hansen et al. 1994; Davis et al. 1998; Jefferson et al. 2008). Several studies have suggested that pygmy sperm whales live mostly beyond the continental shelf edge, whereas dwarf sperm whales tend to occur closer to shore, often over the continental shelf (Rice 1998; Wang et al. 2002; MacLeod et al. 2004). Barros et al. (1998), on the other hand, suggested that dwarf sperm whales could be more pelagic and dive deeper than pygmy sperm whales. It has also been suggested that the pygmy sperm whale is more temperate and the dwarf sperm whale more tropical, based at least partially on live sightings at sea from a large database from the eastern tropical Pacific (Wade and Gerrodette 1993). This idea is also supported by the distribution of strandings in South American waters (Muñoz-Hincapié et al. 1998).

*Kogia* sp. were sighted during surveys off St. Helena during August–October 2004 (Clingham et al. 2013). There are no records of *Kogia* sp. in the offshore waters of the proposed survey area (OBIS 2015). The only records in the OBIS database for the South Atlantic are for Africa; more than 50 records of *K. breviceps* and 22 records of *K. sima* exist for southwestern Africa (OBIS 2015). In addition, both species have been reported for southwestern Brazil (de Oliveira Santos et al. 2010).

### 3.3.2.3 Cuvier's Beaked Whale (*Ziphius cavirostris*)

Cuvier's beaked whale is probably the most widespread and common of the beaked whales, although it is not found in high-latitude polar waters (Heyning 1989). It is rarely observed at sea and is known mostly from strandings; it strands more commonly than any other beaked whale (Heyning 1989). Cuvier's beaked whale is found in deep water over and near the continental slope (Gannier and Epinat 2008; Jefferson et al. 2008).

In the South Atlantic, there are stranding records for Brazil, Uruguay, Argentina, the Falkland Islands, and South Africa (MacLeod et al. 2006). Records for Brazil include one stranding at Trindade Island (Fisch and Port 2013). Sighting records exist for nearshore Brazil, South Africa, the central South Atlantic, the Southern Ocean (Findlay et al. 1992; MacLeod et al. 2006), Gabon (Weir 2007a), and Angola (Best 2007). Bester and Ryan (2007) suggested that Cuvier's beaked whales likely occur in the Tristan da Cunha archipelago. There are no OBIS records for the offshore waters of the proposed survey area (OBIS 2015).

### 3.3.2.4 Arnoux's Beaked Whale (*Berardius arnuxii*)

Arnoux's beaked whale is distributed in deep, cold, temperate and subpolar waters of the Southern Hemisphere, with most records for southeastern South America, the Falkland Islands, the Antarctic Peninsula, South Africa, New Zealand, and southern Australia (MacLeod et al. 2006; Jefferson et al. 2008). It typically occurs south of 40°S (Jefferson et al. 2008), but has been reported as far north as 24°S (Kasuya 2009). Arnoux's beaked whales likely occur in the Tristan da Cunha archipelago (Bester and Ryan 2007). There are no OBIS records for the offshore waters of the proposed survey area (OBIS 2015).

### 3.3.2.5 Shepherd's Beaked Whale (*Tasmacetus shepherdi*)

Based on known records, it is likely that Shepherd's beaked whale has a circumpolar distribution in the cold temperate waters of the Southern Hemisphere (Mead 1989a). It is primarily known from strandings, most of which have been recorded in New Zealand (Pitman et al. 2006; Mead 2009). The Tristan da Cunha archipelago has the second highest number of strandings (Mead 2009) and is thought to be a concentration area for Shepherd's beaked whales (Bester and Ryan 2007; Best et al. 2009). Pitman et al. (2006) and Best et al. (2009) reported six stranding records for Tristan da Cunha and possible

sightings on the Tristan Plateau (2 sightings of 10 whales on 17 November 1985 near 37.3°S, 12.5°W) and Gough Island (one sighting of 4–5 animals). Another stranding of two whales on Tristan da Cunha occurred on 13 January 2012 (Best et al. 2014).

Additional records in the South Atlantic include a sighting in the Scotia Sea and several strandings in Argentina (Grandi et al. 2005; MacLeod et al. 2006; Pitman et al. 2006; Best et al. 2009; Mead 2009). Based on the known distributional range of Shepherd's beaked whale (MacLeod et al. 2006; Jefferson et al. 2008), the proposed survey area is at the northernmost extent of its range. There are no records for pelagic waters of the South Atlantic in the OBIS database (OBIS 2015).

#### **3.3.2.6 Southern Bottlenose Whale (*Hyperoodon planifrons*)**

The southern bottlenose whale is found throughout the Southern Hemisphere from 30°S to the ice edge, with most sightings reported between ~57°S and 70°S (Jefferson et al. 2008). It is apparently migratory, occurring in Antarctic waters during summer (Jefferson et al. 2008). Several sighting and stranding records exist for southeastern South America, the Falkland Islands, South Georgia Island, and South Africa, and numerous sightings have been reported for the Southern Ocean (Findlay et al. 1992; MacLeod et al. 2006). The Falkland Islands/Tierra del Fuego area is considered a beaked whale key area (MacLeod and Mitchell 2006). Southern bottlenose whales were regularly seen there during September–February 1998–2001 (White et al. 2002).

Southern bottlenose whales likely occur in the Tristan da Cunha archipelago (Bester and Ryan 2007). The proposed survey area is at the northernmost extent of the southern bottlenose whale's distribution range (Best 2007; Jefferson et al. 2008). There is one record in the OBIS database of a sighting in the central South Atlantic, which was made by the U.K. Royal Navy on 14 December 1999 at 37.1°S, 12.3°W (Maughan 2003).

#### **3.3.2.7 Hector's Beaked Whale (*Mesoplodon hectori*)**

Hector's beaked whale is thought to have a circumpolar distribution in temperate waters of the Southern Hemisphere (Pitman 2009). Based on the number of stranding records for the species, it appears to be relatively rare. Nonetheless, in the South Atlantic, strandings have been reported for southern Brazil, Argentina, the Falkland Islands, and South Africa (MacLeod et al. 2006). There are no OBIS records for this species for the South Atlantic (OBIS 2015).

#### **3.3.2.8 True's Beaked Whale (*Mesoplodon mirus*)**

True's beaked whale has a disjunct, antitropical distribution (Jefferson et al. 2008). In the Southern Hemisphere, it is known to occur in South Africa, South America, and Australia (Findlay et al. 1992; MacLeod and Mitchell 2006; MacLeod et al. 2006). These areas may comprise three separate populations; the region of South Africa in the Indian Ocean is considered a key beaked whale area (MacLeod and Mitchell 2006). In the South Atlantic, True's beaked whale has stranded on Tristan da Cunha (Best et al. 2009). Records also exist for South Africa and Brazil (de Souza et al. 2005; MacLeod et al. 2006; Best et al. 2009). Based on stranding and sighting data, the proposed survey area is part of the possible range of True's beaked whale (MacLeod et al. 2006; Best 2007; Jefferson et al. 2008). There are no OBIS records for the offshore waters of the proposed survey area (OBIS 2015).

### 3.3.2.9 Gervais' Beaked Whale (*Mesoplodon europaeus*)

Although Gervais' beaked whale is generally considered to be a North Atlantic species, it likely occurs in deep waters of the temperate and tropical Atlantic Ocean in both the Northern and Southern hemispheres (Jefferson et al. 2008). Stranding records have been reported for Brazil and Ascension Island in the central South Atlantic (MacLeod et al. 2006). The southernmost stranding record was reported for São Paulo, Brazil, possibly expanding the known distributional range of this species southward (de Oliveira Santos et al. 2003). Although the distribution range of Gervais' beaked whale is not known to extend as far south as the proposed survey area, this species might range as far south as Uruguay and Angola in the South Atlantic (MacLeod et al. 2006; Jefferson et al. 2008). There are no OBIS records for the South Atlantic (OBIS 2015).

### 3.3.2.10 Gray's Beaked Whale (*Mesoplodon grayi*)

Gray's beaked whale is thought to have a circumpolar distribution in temperate waters of the Southern Hemisphere (Pitman 2009). It primarily occurs in deep waters beyond the edge of the continental shelf (Jefferson et al. 2008). Some sightings have been made in very shallow water, usually of sick animals coming in to strand (Gales et al. 2002; Dalebout et al. 2004).

In the South Atlantic, several stranding records exist for the southeast coast of South America, the Falkland Islands, and South Africa (Findlay et al. 1992; MacLeod et al. 2006; Otley 2012; Otley et al. 2012). Additionally, one sighting was reported off the southwestern tip of South Africa (MacLeod et al. 2006). There are numerous sighting records from Antarctic and sub-Antarctic waters (MacLeod et al. 2006); in summer months, Gray's beaked whales appear near the Antarctic Peninsula and along the shores of the continent (sometimes in the sea ice). Gray's beaked whales likely occur in the Tristan da Cunha archipelago (Bester and Ryan 2007). There are no OBIS records for the offshore waters of the proposed survey area (OBIS 2015).

### 3.3.2.11 Andrew's Beaked Whale (*Mesoplodon bowdoini*)

Andrew's beaked whale has a circumpolar distribution in temperate waters of the Southern Hemisphere (Baker 2001; Pitman 2009). It is known only from stranding records between 32°S and 55°S, with more than half of the strandings occurring in New Zealand (Jefferson et al. 2008). In the South Atlantic, Andrew's beaked whales have also stranded in the Tristan da Cunha archipelago, the Falkland Islands, and Uruguay (Baker 2001; Laporta et al. 2005; MacLeod et al. 2006; Best et al. 2009). Based on its known distribution range (MacLeod et al. 2006; Jefferson et al. 2008), the proposed survey area is at the northernmost extent of its range in the South Atlantic. There are no OBIS records for the South Atlantic (OBIS 2015).

### 3.3.2.12 Strap-toothed Beaked Whale (*Mesoplodon layardii*)

The strap-toothed beaked whale is thought to have a circumpolar distribution in temperate and sub-antarctic waters of the Southern Hemisphere, mostly between 32° and 63°S (MacLeod et al. 2006; Jefferson et al. 2008). It might undertake limited migration to warmer waters during the austral winter (Pitman 2009). Strap-toothed whales are thought to migrate northward from Antarctic and sub-Antarctic latitudes during April–September (Sekiguchi et al. 1995).

In the South Atlantic, stranding records have been reported for Brazil, Uruguay, Argentina, the Falkland Islands, South Georgia, and South Africa (Findlay et al. 1992; Pinedo et al. 2002a; MacLeod et al. 2006; Otley et al. 2012). In addition, sightings have been reported off the southern tip of Africa, near

Bouvet Island, and in the Southern Ocean (MacLeod et al. 2006). Bester and Ryan (2007) suggested that strap-toothed beaked whales likely occur in the Tristan da Cunha archipelago (Bester and Ryan 2007). There are no OBIS records for the offshore waters of the proposed survey area (OBIS 2015).

### **3.3.2.13 Blainville's Beaked Whale (*Mesoplodon densirostris*)**

Blainville's beaked whale is found in tropical and warm temperate waters of all oceans (Jefferson et al. 2008; Pitman 2009). It has the widest distribution throughout the world of all *Mesoplodon* species (Mead 1989b; Pitman 2009). In the South Atlantic, strandings have been reported for southern Brazil and South Africa (Findlay et al. 1992; MacLeod et al. 2006). A sighting was made during a boat survey off St. Helena in November 2007 (Clingham et al. 2013). There are no OBIS records for the offshore waters of the proposed survey area (OBIS 2015).

### **3.3.2.14 Spade-toothed Beaked Whale (*Mesoplodon traversii*)**

The spade-toothed beaked whale is the name proposed for the species formerly known as Bahamonde's beaked whale (*M. bahamondi*); genetic evidence has shown that it belongs to the species first identified by Gray in 1874 (van Helden et al. 2002). The spade-toothed beaked whale is considered relatively rare and is known from only four records, three from New Zealand and one from Chile (Thompson et al. 2012). Although no records currently exist for the South Atlantic, the known records at similar latitudes suggest that the spade-toothed beaked whale could occur in the proposed survey area.

### **3.3.2.15 Rough-toothed Dolphin (*Steno bredanensis*)**

The rough-toothed dolphin is distributed worldwide in tropical, subtropical, and warm temperate waters (Miyazaki and Perrin 1994). It is generally seen in deep, oceanic water, although it is known to occur in coastal waters of Brazil (Flores and Ximenez 1997). One rough-toothed dolphin sighting was made during an August–September 2010 survey off Brazil from Vitória at ~20°S, 40°W to Trindade and Martim Vaz islands; the group of 30 individuals was seen in association with two minke whales at ~19.1°S, 35.1°W on 21 August (Wedekin et al. 2014). Rough-toothed dolphins have also been sighted at St. Helena (MacLeod and Bennett 2007; Clingham et al. 2013) and at 32.5°S, 2.0°W (Peters 1876 in Best et al. 2009).

For the South Atlantic, there are 42 records of rough-toothed dolphin in the OBIS database, including two offshore records to the far north of the proposed survey area, one record for Brazil, one for South Africa, and one for Gabon (OBIS 2015). Rough-toothed dolphins have also been sighted off Gabon (de Boer 2010) and Angola (Weir 2007a, 2010).

### **3.3.2.16 Common Bottlenose Dolphin (*Tursiops truncatus*)**

The bottlenose dolphin occurs in tropical, subtropical, and temperate waters throughout the world (Wells and Scott 2009). In the South Atlantic, it occurs as far south as South Africa and Tierra del Fuego (Wells and Scott 2009; Goodall et al. 2011), and strandings have been reported for the Falkland Islands (Otley 2012). In many parts of the world, coastal and offshore ecotypes have been distinguished based on morphological, ecological, and physiological features (Jefferson et al. 2008).

Three sightings of common bottlenose dolphins were made at Trindade Island during December 2009–February 2010 surveys; two sightings of 15 individuals were made during December and a single bottlenose dolphin was sighted on 23 February (Souza de Carvalho and Rossi-Santos 2011). Additionally, two sightings of common bottlenose dolphins were made during an August–September 2010 survey

from Vitória at ~20°S, 40°W to Trindade and Martim Vaz islands; both groups were seen on 30 August at Trindade Island, near 20.5°S, 29.3°W (Wedekin et al. 2014). Common bottlenose dolphins have also been sighted near St. Helena (MacLeod and Bennett 2007; Clingham et al. 2013).

Based on the distribution map in Jefferson et al. (2008), the waters of the proposed survey area are part of the secondary range of the common bottlenose dolphin. Although there are no records of common bottlenose dolphins in the offshore waters of the proposed survey area, in nearshore waters there are 3 records for Brazil, 98 for Argentina, and 27 for southwestern Africa (OBIS 2015). Common bottlenose dolphins have also been sighted off Gabon (de Boer 2010) and Angola (Weir 2007a, 2010).

### **3.3.2.17 Pantropical Spotted Dolphin (*Stenella attenuata*)**

The pantropical spotted dolphin is distributed worldwide in tropical and some subtropical waters (Perrin 2009a), between ~40°N and 40°S (Jefferson et al. 2008). It is one of the most abundant cetaceans and is found in coastal, shelf, slope, and deep waters (Perrin 2009a). Based on the distribution maps in Jefferson et al. (2008) and Best (2007), the proposed survey area is within the distributional range of the pantropical spotted dolphin; however, based on maps provided by Moreno et al. (2005), the western survey area might not overlap its distributional range. For the South Atlantic, there is one record for Brazil and one record for South Africa (OBIS 2015). Pantropical spotted dolphins have been sighted off Brazil (Moreno et al. 2005), Gabon (de Boer 2010), Angola (Weir 2007a, 2010), and St. Helena (MacLeod and Bennett 2007; Clingham et al. 2013).

### **3.3.2.18 Spinner Dolphin (*Stenella longirostris*)**

The spinner dolphin is pantropical in distribution, with a range nearly identical to that of the pantropical spotted dolphin, including oceanic tropical and sub-tropical waters between 40°N and 40°S (Jefferson et al. 2008). It is generally considered a pelagic species (Perrin 2009b), but can also be found in coastal waters and around oceanic islands (Rice 1998). Spinner dolphins are extremely gregarious, and usually form large schools in the open sea and small ones in coastal waters (Perrin and Gilpatrick 1994).

Although its distributional range appears to be to the north of the proposed survey area in the South Atlantic (Best 2007; Jefferson et al. 2008), it is possible that spinner dolphins occur at the western end of the proposed transect line (see Moreno et al. 2005). There are two OBIS records for the South Atlantic: one sighting north of the Falkland Islands at 47.4°S, 54.2°W made by the U.K. Royal Navy in November 2011 (Maughan 2003) and another off Brazil at 23.1°S, 43.1°W during April 1988 (OBIS 2015). Other sightings off Brazil have also been reported by Moreno et al. (2005).

### **3.3.2.19 Clymene Dolphin (*Stenella clymene*)**

The Clymene dolphin only occurs in tropical and subtropical waters of the Atlantic Ocean (Jefferson et al. 2008). It inhabits areas where water depths are 700–4500 m or deeper (Fertl et al. 2003). In the western Atlantic, it occurs from New Jersey to Florida, the Caribbean Sea, the Gulf of Mexico, and south to Venezuela and Brazil (Würsig et al. 2000; Fertl et al. 2003).

Although currently available information indicates that the proposed survey area might not overlap with the distributional range of the Clymene dolphin (e.g., Fertl et al. 2003; Best 2007; Jefferson et al. 2008), it is possible that some individuals could be encountered at the western end of the survey transect (see Moreno et al. 2005). There are no OBIS records for the South Atlantic (OBIS 2015).

### 3.3.2.20 Striped Dolphin (*Stenella coeruleoalba*)

The striped dolphin has a cosmopolitan distribution in tropical to warm temperate waters from ~50°N to 40°S (Perrin et al. 1994; Jefferson et al. 2008). It occurs primarily in pelagic waters, but has been observed approaching shore where there is deep water close to the coast (Jefferson et al. 2008). In the South Atlantic, it is known to occur along the coast of South America, from Brazil to Argentina, and along the west coast of Africa (Jefferson et al. 2008).

The proposed survey area might possibly overlap the distributional range of the striped dolphin (see Moreno et al. 2005; Best 2007; Jefferson et al. 2008). There are 58 OBIS records for the South Atlantic, including nearshore waters of Brazil, Uruguay, Argentina, Angola, and South Africa (OBIS 2015), and 19 records for offshore waters near 8.4°S, 24.4°W made during tuna fisheries research (Cauquil et al. 2012).

### 3.3.2.21 Fraser's Dolphin (*Lagenodelphis hosei*)

Fraser's dolphin is a tropical oceanic species distributed between 30°N and 30°S that generally inhabits deeper, offshore water (Dolar 2009). Strandings in more temperate waters, such as in Uruguay, are likely extralimital (Dolar 2009). For the South Atlantic, there are no OBIS records for the offshore waters of the proposed survey area (OBIS 2015), but there are 24 records for the coast of South America (Reyes 2006). Fraser's dolphin has also been sighted in the Gulf of Guinea and off Angola (Weir et al. 2008; Weir 2010).

### 3.3.2.22 Short-beaked Common Dolphin (*Delphinus delphis*)

The short-beaked common dolphin is found in tropical and warm temperate oceans around the world (Jefferson et al. 2008). It is the most abundant dolphin species in offshore areas of warm-temperate regions in the North Atlantic and Pacific (Perrin 2009c). It can be found in oceanic or coastal habitats; it is common in coastal waters 200–300 m deep and is also associated with prominent underwater topography, such as seamounts (Evans 1994). Although Jefferson et al. (2008) and Perrin (2009c) reported that its occurrence in the South Atlantic is uncertain, Best (2007) reported numerous records for the waters off southern Africa. Offshore records to the southwest of the proposed survey area have been made near 40°S, 13°W, and 37°S, 9°W (Best 2007). The short-beaked common dolphin has also been reported for the waters to the east of South Africa (Samai et al. 2007). For the South Atlantic, there are 4 OBIS records for South America and nearly 80 records for southwestern Africa (OBIS 2015).

### 3.3.2.23 Hourglass Dolphin (*Lagenorhynchus cruciger*)

The hourglass dolphin occurs in all parts of the Southern Ocean south of ~45°S, with most sightings between 45°S and 60°S (Goodall 2009). However, some sightings have been made as far north as 33°S, so the possible range for this species might extend northward to the proposed survey area (Jefferson et al. 2008). Although it is pelagic, it is also sighted near banks and islands (Goodall 2009). Bester and Ryan (2007) reported that the hourglass dolphin might occur south of Gough Island. There are 8 records for the western South Atlantic in the OBIS database, including records for Argentina, the Falkland Islands, and South Georgia (OBIS 2015).

### 3.3.2.24 Southern Right Whale Dolphin (*Lissodelphis peronii*)

The southern right whale dolphin is distributed between the Subtropical and Antarctic convergences in the Southern Hemisphere, generally between ~30°S and 65°S (Jefferson et al. 2008). It is

sighted most often in cool, offshore waters, although it is sometimes seen near shore where coastal waters are deep (Jefferson et al. 2008), such as off Namibia (Rose and Payne 1991; Findlay et al. 1992). Cold-water currents, such as the Malvinas current off Brazil, might also influence its distribution, extending its range northward (Lipsky 2009). Bester and Ryan (2007) suggested that southern right whale dolphins might be visitors to the southern waters of the Tristan da Cunha archipelago. One was captured near Tristan da Cunha on 10 December 1847 at 37.1°S, 11.6°W (Cruickshank and Brown 1981 in Best et al. 2009). There are no records for the South Atlantic in the OBIS database (OBIS 2015).

### **3.3.2.25 Melon-headed Whale (*Peponocephala electra*)**

The melon-headed whale is an oceanic species found worldwide in tropical and subtropical waters from ~40°N to 35°S (Jefferson et al. 2008). It occurs most often in deep offshore waters and occasionally in nearshore areas where deep oceanic waters occur near the coast (Perryman 2009). Off the west coast of Africa, melon-headed whales have been recorded off Gabon (de Boer 2010) and Angola (Weir 2007a, 2010), and an extralimital record exists for South Africa (Jefferson et al. 2008). Based on the distribution map in Jefferson et al. (2008), the proposed survey area is at the southernmost extent of the melon-headed whale's range. There is a single record for the South Atlantic off South Africa, held by the Iziko South African museum (OBIS 2015); this record is considered to be extralimital (Jefferson et al. 2008).

### **3.3.2.26 Pygmy Killer Whale (*Feresa attenuata*)**

The pygmy killer whale has a worldwide distribution in tropical and subtropical waters (Donahue and Perryman 2009), generally not ranging south of 35°S (Jefferson et al. 2008). It is known to inhabit the warm waters of the Indian, Pacific, and Atlantic oceans (Jefferson et al. 2008). It can be found in nearshore areas where the water is deep and in offshore waters (Jefferson et al. 2008).

Based on the distribution map in Jefferson et al. (2008), the proposed survey area is at the southernmost extent of the pygmy killer whale's range. There are no records for the offshore waters of the proposed survey area, but there are 5 records at the Iziko South African Museum for the southwestern coast of Africa (OBIS 2015). In addition, there is one stranding record for Brazil (de Oliveira Santos et al. 2010).

### **3.3.2.27 False Killer Whale (*Pseudorca crassidens*)**

The false killer whale is found worldwide in tropical and temperate waters, generally between 50°N and 50°S (Odell and McClune 1999). It is widely distributed, but not abundant anywhere (Carwardine 1995). The false killer whale generally inhabits deep, offshore waters, but sometimes is found over the continental shelf and occasionally moves into very shallow water (Jefferson et al. 2008; Baird 2009). It is gregarious and forms strong social bonds, as is evident from its propensity to strand en masse (Baird 2009).

Based on the distribution map in Jefferson et al. (2008), the primary range of the false killer whale in the South Atlantic extends along the coast of South America and Africa, and the open waters of the South Atlantic are considered part of its secondary range, extending south to ~29°S. False killer whales are known to prey on the Uruguayan pelagic longline fishery (Passadore et al. 2015a). They have also been recorded around St. Helena (Clingham et al. 2013). Although there are no OBIS records of false killer whales for the offshore waters of the proposed survey area, there are 91 records for the South Atlantic, including offshore waters off South America and nearshore waters off southwestern Africa (OBIS 2015).

### 3.3.2.28 Killer Whale (*Orcinus orca*)

The killer whale is cosmopolitan and globally abundant; it has been observed in all oceans of the world (Ford 2009). It is very common in temperate waters but also occurs in tropical waters (Heyning and Dahlheim 1988), and it inhabits coastal as well as offshore regions (Budylenko 1981).

Based on sightings by whaling vessels between 1960 and 1979, killer whales are distributed throughout the South Atlantic (Budylenko 1981; Mikhalev et al. 1981). Mikhalev et al. (1981) noted that they appear to migrate from warmer waters during the winter to higher latitudes during the summer. Sightings of killer whale pods of 1 to >100 individuals were made near the proposed survey area during November–April, with most sightings during November and December (Budylenko 1981; Mikhalev et al. 1981). Densities along 31°S likely are relatively low (Forney and Wade 2006).

Pinedo et al. (2002b) noted that killer whales are relatively common off southern Brazil, and they are also known to occur off Gabon (de Boer 2010), Angola (Weir 2007a; Weir et al. 2010), as well as Namibia, and South Africa (Findlay et al. 1992). Killer whales are known to prey on longline catches in the waters off southern Brazil (Dalla Rosa and Secchi 2007) and South Africa (Williams et al. 2009). They are also known to prey on the Uruguayan pelagic longline fishery (Passadore et al. 2015a). One predation event by a killer whale was recorded for waters just to the north of the proposed survey area, at ~29°S, 28°S, with several other predation events and sightings to the northwest (Passadore et al. 2014, 2015a). Killer whales occur in the Uruguayan fishing grounds throughout the year, but most frequently during autumn and winter and ~300–750 km from shore along the shelf break (Passadore et al. 2014).

Killer whales are considered scarce in the Tristan da Cunha archipelago (Bester and Ryan 2007), but they have been sighted there during September and October (Best et al. 2009). They have also been recorded for waters near St. Helena (Clingham et al. 2013). One killer whale sighting was made during an August–September 2010 survey from Vitória at ~20°S, 40°W to Trindade and Martim Vaz islands; the pod was seen to the east of Vitória, near 20.5°S, 37.2°W, on 4 September (Wedekin et al. 2014). There are ~40 records of killer whales for the South Atlantic in the OBIS database, including records for offshore and nearshore waters of South America (OBIS 2015). The record closest to the proposed survey area was made by the U.K. Royal Navy on 26 November 1996 at 37.0°S, 12.3°W, ~1600 km south of the proposed survey area (Maughan 2003).

### 3.3.2.29 Short-finned (*Globicephala macrorhynchus*) and Long-finned (*G. melas*) Pilot Whales

The short-finned pilot whale is found in tropical and warm temperate waters, and the long-finned pilot whale is distributed antitropically in cold temperate waters (Olson 2009). The ranges of the two species show little overlap (Olson 2009). Short-finned pilot whale distribution does not generally range south of 40°S (Jefferson et al. 2008).

Long-finned pilot whales are considered uncommon in Tristan waters (Bester and Ryan 2007); pilot whales have stranded on the islands of the Tristan da Cunha archipelago, although it is uncertain what species they were (Best et al. 2009). There are no records of pilot whales in the offshore waters of the proposed survey area in the OBIS database, but there are >90 short-finned pilot whale records for the waters off South America and Africa and a single record of long-finned pilot whales off Brazil (OBIS 2015). In addition, there are records of long-finned pilot whales for South Africa (Findlay et al. 1992) and a stranding record at Tierra del Fuego, Argentina (Clarke and Goodall 1994).

### 3.3.3 Pinnipeds

#### 3.3.3.1 Subantarctic Fur Seal (*Arctocephalus tropicalis*)

The subantarctic fur seal is distributed throughout the Southern Hemisphere (Jefferson et al. 2008). It breeds on subantarctic and subtemperate islands north of the Antarctic Polar Front (Arnould 2009). In the South Atlantic, the subantarctic fur seal breeds at the Tristan da Cunha archipelago (Bester and Ryan 2007). The largest breeding population is found on Gough Island (Bester et al. 2006). Arnould (2009) reported that the population on Gough Island numbers more than 200,000 seals. Bester and Ryan (2007) reported that ~80% of the world population (~300,000 seals) is found on Gough Island. The world population is estimated at >310,000 individuals (Arnould 2009). A few pups are also born at Tristan da Cunha Island, and the subantarctic fur seal can also be found on Nightingale and Inaccessible islands (Hofmeyr et al. 1997). Breeding/pupping at Tristan da Cunha archipelago occurs during late spring/early summer (Bester and Ryan 2007).

Vagrant subantarctic fur seals have been reported in South Africa (Shaughnessy and Ross 1980) and along the coast of Brazil (Ferreira et al. 2008; Oliveira et al. 2011). Most of the seals found in Brazil are from Gough Island, although others seem to come from breeding colonies much farther away, such as the Crozet Islands in the Indian Ocean (Ferreira et al. 2008). The at-sea distribution of subantarctic fur seals is poorly understood, although they are often seen in the waters between Tristan da Cunha and South Africa (Bester and Ryan 2007). Based on the distribution map in Jefferson et al. (2008), the pelagic waters of the proposed survey area are within the possible range of the subantarctic fur seal. There are no OBIS records for the offshore waters of the proposed survey area, but there are 13 OBIS records for South Africa, 21 records for pelagic waters near 40.3°S, 9.9°W, and one record for coastal waters of southern Brazil (OBIS 2015).

#### 3.3.3.2 Southern Elephant Seal (*Mirounga leonina*)

The southern elephant seal has a near circumpolar distribution in the Southern Hemisphere (Jefferson et al. 2008), with breeding sites located on islands throughout the subantarctic (Hindell and Perrin 2009). In the South Atlantic, southern elephant seals breed at Patagonia, South Georgia, and other islands of the Scotia Arc, the Falklands, Bouvet Island, and Tristan da Cunha archipelago (Bester and Ryan 2007). Numbers on Tristan da Cunha have been low since southern elephant seals were hunted there (Bester and Ryan 2007). At Gough Island, the breeding season takes place during the austral spring; pups are born in October and start to disperse in December (Bester and Ryan 2007). Between 1973 and 1998, the number of births at Gough Island declined from 38 pups in 1975 to 11 in 1997 (Bester et al. 2001). Immature animals also haul out on Tristan da Cunha and Inaccessible islands (Bester and Ryan 2007).

When not breeding (September–October) or molting (November–April), southern elephant seals range throughout the Southern Ocean from areas north of the Antarctic Polar Front to the pack ice of the Antarctic (Hindell and Perrin 2009). Southern elephant seals tagged at South Georgia showed long-range movements from ~April through October into the open Southern Ocean and to the shelf of the Antarctic Peninsula (McConnell and Fedak 1996); none were tracked as far north as the proposed survey area. One adult male that was sighted on Gough Island had previously been tagged at Marion Island in the Indian Ocean (Reisinger and Bester 2010). Vagrant southern elephant seals, mainly consisting of juvenile and subadult males, have been documented in Uruguay and Brazil (Lewis et al. 2006a; Oliveira et al. 2011).

Based on the distribution map in Jefferson et al. (2008), the proposed survey area is at the northernmost extent of the secondary range of the southern elephant seal. For the South Atlantic, there are more than 2000 OBIS records for the nearshore and offshore waters of South America and along the southwestern coast of Africa (OBIS 2015); most of the records (1793) are for waters of the Patagonian Large Marine Ecosystem (Campagna et al. 2006). The closest records (three) to the proposed survey area were made at 29.3°S, 33.8°W (Lewis et al. 2006b), ~500 km northwest of the proposed survey area.

### 3.4 Sea Turtles

Five species of sea turtles could occur in the offshore waters of the proposed study area. The leatherback turtle is listed as **Endangered** under the ESA; the Southwest Atlantic Subpopulation is listed as *Critically endangered* on the IUCN red list of threatened species (IUCN 2015), whereas the Southeast Atlantic Subpopulation is listed as *Data deficient*. The hawksbill turtle is also listed as **Endangered** under the ESA; on the IUCN red list of threatened species (IUCN 2015), it is listed as *Critically endangered*. The green turtle, including the proposed South Atlantic Ocean Distinct Population Segment or DPS (NMFS and USFWS 2015), olive ridley turtle, and loggerhead turtle (South Atlantic Ocean DPS) are listed as **Threatened** under the ESA. On the IUCN Red List of Threatened Species (IUCN 2015), the green and loggerhead turtles are listed as *Endangered*, and the olive ridley turtle is listed as *Vulnerable*.

General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of sea turtles is given in § 3.4.1 of the PEIS. The general distribution of sea turtles in the southwest Atlantic is discussed in § 3.4.3 of the PEIS. The rest of this section focuses on their distribution in the proposed offshore survey area across the MAR in the South Atlantic Ocean.

#### 3.4.1 Leatherback Turtle (*Dermochelys coriacea*)

The leatherback turtle is the most widely distributed sea turtle, occurring from 71°N to 47°S (Eckert et al. 2012). During the non-breeding season, it ranges far from its tropical and subtropical nesting grounds, which are located from 38°N to 34°S (Eckert et al. 2012). In the South Atlantic, distinct populations nest along the coasts of Brazil and Gabon (Dutton et al. 2013). The nesting colony at Gabon is the largest leatherback rookery in the world, with ~5865–20,499 nesting females annually (Witt et al. 2009). Nesting colonies also occur along other parts of central western Africa, including Angola and Congo (Weir et al. 2007; Parnell et al. 2007; Eckert et al. 2012). In Brazil, nesting occurs from September to February, with a peak in November (Thomé et al. 2007); in western Africa, nesting occurs from ~September to April (Deem et al. 2007; Parnell et al. 2007; Weir et al. 2007).

A total of 106 leatherback turtles have been equipped with tags in coastal areas of South America and central West Africa from June 1995 to February 2010 (Fossette et al. 2014). Several made migrations across the South Atlantic Ocean, passing several hundred kilometers to the north of the proposed survey area (Fossette et al. 2014). Although Sale and Luschi (2009) suggested that some leatherbacks are carried by currents, Galli et al. (2012) reported that leatherbacks actively swim during travel rather than drift along with currents.

Twenty-five adult female turtles were satellite-tagged at Gabon nesting beaches during 2006–2010; they showed three different dispersal strategies, including movements to (1) the equatorial Atlantic, (2) temperate areas of South America, and (3) temperate regions of southern Africa (Witt et al. 2011). Five turtles made migrations across the South Atlantic to or en route to South America (Witt et al. 2011); all migrations were undertaken to the north of the proposed survey area. All four turtles that were flipper-tagged during the 2002–2003 nesting season in Gabon made migrations across the South Atlantic to

South America and were found along the coasts of Brazil and Argentina (Billes et al. 2006). Vargas et al. (2008) reported that pelagic non-nesting leatherbacks occur along the southern coast of Brazil. Evidence that turtles from western Africa migrate to feeding grounds off the coast of South America also comes from recent genetic analysis (Dutton et al. 2013; Prosdocimi et al. 2014).

Turtles outfitted with satellite tags at nesting beaches in southeastern Brazil during the 2005–2006 nesting season dispersed as far as 160 km from land during the internesting period (Almeida et al. 2011a). After nesting, females traveled to feeding areas in coastal waters of Brazil, Uruguay, and Argentina (Almeida et al. 2011a). One turtle traveled across the Atlantic, north of the proposed survey area, to the coast off Angola (Almeida et al. 2011a). Of six turtles that were tagged in Surinam and French Guiana, one made a trans-oceanic migration to Ghana, West Africa, whereas the rest migrated northward to the U.S., Mexico, and Venezuela (Pritchard 1976).

For the South Atlantic, there are nearly ~300 OBIS records of leatherback turtles along the coasts of South America and Africa, including nearshore and offshore sightings, but there are no records for the offshore waters of the proposed survey area (OBIS 2015). The closest record is on 29 June 2006 at 36.5°S, 0.5°E (Coyne and Godley 2005), more than 1000 km southeast of the proposed survey area.

### 3.4.2 Hawksbill Turtle (*Eretmochelys imbricata*)

The hawksbill turtle is the most tropical of all sea turtles, generally occurring between ~30°N and ~30°S (Eckert 1995). In the Atlantic Ocean, most nesting beaches are in the Caribbean Sea as far north as Cuba and the Bahamas (NMFS and USFWS 2013). In the South Atlantic, the largest nesting ground for hawksbill turtles is located in the state of Bahia, Brazil (Marcovaldi et al. 2012); there are also much smaller nesting sites located in the Gulf of Guinea, Africa (NMFS and USFWS 2013).

During 2005–2006, 1530–1820 nests were found at Brazilian nesting grounds (Marcovaldi et al. 2007). Nesting takes place from November through March, with peak egg laying during December–February (Marcovaldi et al. 2007). Fifteen adult females were satellite-tagged at their nesting beaches, six of which were determined to be hawksbill-loggerhead hybrids; during the inter-nesting period, all 15 remained in coastal waters of Bahia (Marcovaldi et al. 2012). Post-nesting migrations occurred mostly over the shelf; hawksbill turtles primarily visited foraging sites at 9–17.5°S, whereas hybrids foraged at 0–5°S (Marcovaldi et al. 2012). One turtle traveled into offshore waters (Marcovaldi et al. 2012). Other long-distance movements offshore have also been reported, including a juvenile hawksbill turtle that was tagged in Brazil during January 1990 and captured in Dakar, Senegal, in July 1990 (Marcovaldi and Filippini 2001). Another sub-adult tagged in November 1994 in Brazil was captured off Gabon in April 1999 (Bellini et al. 2000).

There are ~128 OBIS records of hawksbill turtles in the South Atlantic Ocean, including sightings in nearshore waters of South America and Africa and in pelagic waters (OBIS 2015). The closest OBIS record to the proposed survey area was made on 14 May 2005 near the MAR at 23.5°S, 14.5°W, ~800 km north of the proposed survey area (Coyne and Godley 2005).

### 3.4.3 Loggerhead Turtle (*Caretta caretta*)

The loggerhead is a widely distributed species, occurring in coastal tropical and subtropical waters of the Atlantic, Pacific, and Indian oceans (Dodd 1988). The Brazilian nesting grounds are likely the largest in the world (Marcovaldi and Chaloupka 2007). During the 2003–2004 nesting season, >4800 nests were found along Brazil's beaches (Marcovaldi and Chaloupka 2007). Genetic data suggest that loggerheads in Brazil are comprised of two stocks: a northern stock that consists of Sergipe and Bahia

rookeries, and the southern stock, which includes rookeries at Espírito Santo and Rio de Janeiro (Reis et al. 2010). Nesting along the coast of Brazil occurs from September to February, with peak nesting activity during November and December (Marcovaldi and Chaloupka 2007).

Little information is available on the foraging grounds and post-nesting movements of loggerhead turtles (Dodd 1988; Lemke et al. 2006). Eight turtles tagged at nesting beaches in Brazil during 2001 traveled maximum straight-line distances of up to 1300 km to the south, 200 km to the east, and 1000 km to the north. Most of the post-nesting routes occurred over the shelf, although some turtles briefly traveled off the shelf before retuning to shallower waters (Lemke et al. 2006). Post-nesting females from Bahia, Brazil, that were satellite tagged during 2006 were reported foraging in the coastal waters northern Brazil, in particular Ceará, having traveled distances of up to 2400 km (Marcovaldi et al. 2010). One turtle that was flipper tagged in Brazil was observed several years later in Mexico (Lima et al. 2014), and another that was tagged in Brazil was found dead in Uruguay (Almeida et al. 2000). Trans-oceanic migrations have also been documented; Bolten et al. (1990) reported on a juvenile loggerhead that was tagged in Brazil and migrated to the Azores. In addition, a loggerhead tagged in Brazil in 1986 was recaptured in the Azores in 1989 (Marcovaldi et al. 2000). In South America, foraging grounds are also known off the coast of Argentina (González Carman et al. 2011).

Numerous loggerheads have been taken as bycatch in the longline fishery off Brazil at the Rio Grande Rise (Marcovaldi et al. 2006), just to the southwest of the proposed survey area. For the South Atlantic, the OBIS database shows numerous sightings of loggerhead turtles along the coasts of South America and Africa, and offshore, but there are no records for the offshore waters of the proposed survey area; the closest sightings were made at least 1400 km to the northeast (OBIS 2015).

#### **3.4.4 Olive Ridley Turtle (*Lepidochelys olivacea*)**

The olive ridley turtle has a large range in tropical and subtropical regions in the Pacific, Indian, and South Atlantic oceans (Marcovaldi 2001). It is primarily found in coastal waters, but captures in offshore waters indicate that some individuals occur in pelagic areas (Marcovaldi 2001). In the eastern Atlantic, nesting occurs along the coast of Africa from Liberia to Angola (Fretey et al. 2005), and in the western Atlantic, main rookeries are located in Suriname, French Guiana, and northeastern Brazil (Marcovaldi 2001; Godfrey and Chevalier 2004). Records also exist for as far south as Uruguay (Godfrey and Chevalier 2004). In northeastern Brazil, olive ridley turtles primarily nest during September–March, with peak nesting occurring during November–January (da Silva et al. 2007).

Little is known about the at-sea movements of olive ridleys (Marcovaldi 2001). Maxwell et al. (2011) reported on movements of olive ridleys that were tagged at nesting beaches in Gabon and the Republic of Congo; satellite-tracked turtles traveled a mean distance of 27.7 km and a maximum of 97 km from shore; inter-nesting movements also occurred between the two countries. Olive ridley turtles flipper tagged in Brazil during 1990–1995 were recaptured again along the coast of Brazil (Marcovaldi et al. 2000). Pritchard (1976) reported that olive ridley turtles tagged in the Guianas in South America traveled to Barbados, Trinidad, and Brazil.

For the South Atlantic, there are over 200 OBIS records of olive ridley turtles spanning the waters between Brazil and the west coast of Africa, south to ~18°S (OBIS 2015). Although there are no records for the offshore waters of the proposed survey area, tuna bycatch observer data shows numerous records in pelagic waters of the South Atlantic (Cauquil et al. 2012).

### 3.4.5 Green Turtle (*Chelonia mydas*)

The green turtle is widely distributed in tropical and subtropical waters near continental coasts and around islands, ranging from ~30°N to 30°S (NMFS 2015c). The proposed South Atlantic DPS (NMFS 2015c) is known to nest in Equatorial Guinea, Guinea Bissau, Ascension Island, Venezuela, Suriname, and Brazil (Seminoff et al. 2015). The largest rookery in the DPS is located at Poilão in Guinea Bissau, followed by Ascension Island (Seminoff et al. 2015). In Brazil, major green turtle rookeries are located on oceanic islands, including Rocas Atoll, Fernando de Noronha, and Trindade and Martim Vaz (Gitirana and Souza 2012; Seminoff et al. 2015). Trindade Island is one of the most important nesting sites for green turtles in the Atlantic (Almeida et al. 2011b). From 1982 to 2009, 1333–5261 nests were found there (Almeida et al. 2011b), and during 2008–2010, 2016 turtles were estimated to have nested there (Seminoff et al. 2015).

Important foraging grounds for green turtles are located along the coasts of Brazil (Gitirana and Souza 2012; Naro-Maciel et al. 2012), Uruguay (Rivas-Zinno 2012), and Argentina (e.g., González Carman et al. 2011; Prosdocimi et al. 2012). Most turtles at Brazilian foraging grounds originate from Ascension Island, Surinam, Aves Island, and Trindade Island (Naro-Maciel et al. 2006, 2012; Proietti et al. 2009, 2012). Post-nesting, adult turtles have been shown to migrate from Ascension Island to foraging areas along the coast of Brazil, between 3°S and 22°S (Koch et al. 1969; Mortimer and Carr 1987; Luschi et al. 1998; Hays et al. 2002). Five of six turtles tagged at Ascension Island during April–July 1997 migrated across the South Atlantic Ocean to Brazil; the sixth made shorter trips around Ascension Island (Luschi et al. 1998). In addition, all 10 turtles tagged during May and June 1998 at Ascension Island undertook migrations across the South Atlantic Ocean to Brazil (Papi et al. 2000), all five turtles satellite tagged during May–August 2001 on Ascension Island made trans-oceanic movements to the coast of Brazil (Hays et al. 2002). All trans-oceanic migrations by green turtles to date have occurred far north of the proposed survey area.

Ninety of 91 green turtles tagged in Surinam and French Guiana were recovered along the coast of Brazil (Pritchard 1976). Green turtles tagged in Brazil from 1992 to 1998 were mostly recaptured in other areas of Brazil, but three individuals were recaptured in Senegal, Nicaragua, and Trinidad-Tobago (Marcovaldi et al. 2000). Brazilian coastal waters are also important foraging grounds for juvenile green turtles (Godley et al. 2003). Data from satellite telemetry and flipper tagging showed that juvenile turtles in general exhibit three different movement patterns: (1) long-range movements greater than 100 km, (2) moderate-ranged movements less than 100 km, or (3) residence near the release site (Godley et al. 2003). In the OBIS database, there are ~200 records of green turtles along the coasts of Brazil, Uruguay, and Argentina, as well as offshore from central Brazil, but there are no records for the offshore waters of the proposed survey area (OBIS 2015).

## 3.5 Seabirds

There is a remote possibility that one ESA-listed seabird species, the freira, may occur in the proposed survey area. The freira is listed as *Endangered* under the ESA and on the IUCN Red List of Threatened Species (IUCN 2015). General information on the taxonomy, ecology, distribution and movements, and acoustic capabilities of seabird families are given in § 3.5.1 of the PEIS.

### 3.5.1 Freira (*Pterodroma madeira*)

The freira (also called Zino's or Madeira petrel) is only known to breed on six inaccessible ledges on Mt. Areeiro on the Portuguese island of Madeira (BirdLife International 2015). When the breeding

area was discovered in 1969, there were only seven breeding pairs; the population has since increased to 65–80 pairs (Carboneras et al. 2014). During the breeding season, from April to late September, they are found in the northeast Atlantic, ranging to and from the colony at Madeira. Little information is available on their movements in the non-breeding season (October–March). Preliminary results from geolocator studies indicate that in the non-breeding season, they move to the waters off northeast Brazil, Mauritania, Senegal, and the tropical waters along the south MAR, at least as far south as St. Helena (Carboneras et al. 2014). Although it is highly unlikely that freiras would be encountered in the proposed survey area (St. Helena is located 1900 km to the northeast), it remains a possibility given that the survey takes place in the non-breeding season and our limited knowledge of this species' movements.

### 3.6 Fish, Essential Fish Habitat, and Habitat Areas of Particular Concern

One marine fish species listed under the ESA as *Endangered* could occur in or near the proposed survey area: the Eastern Atlantic DPS of the scalloped hammerhead shark (NMFS 2015a). Globally, the scalloped hammerhead shark is listed as *Endangered* under the IUCN Red list of Threatened Species, but the Southwest Atlantic and Eastern Central Atlantic subpopulations are considered to be *Vulnerable* (IUCN 2015). In addition, there are six marine fish species that are candidates for ESA listing: the Argentine angelshark, angular angelshark, common thresher shark, porbeagle shark, narrownose smooth-hound shark, and Brazilian guitarfish (NMFS 2015d). The Argentine angelshark, angular angel shark, narrownose smooth-hound shark, and Brazilian guitarfish are candidates for listing based on a petition by WildEarth Guardians (2013). The Argentine angelshark, angular angel shark, and narrownose smooth-hound shark are listed as *Endangered* on the IUCN Red List of Threatened Species, the common thresher and porbeagle sharks are listed as *Vulnerable*, and the Brazilian guitarfish is listed as *Critically Endangered* (IUCN 2015). The ESA-listed and candidate species are described below. There are no ESA-listed or candidate marine invertebrate species that could occur in the proposed survey area (NMFS 2015a,d).

#### 3.6.1 Scalloped Hammerhead Shark (*Sphyrna lewini*)

The scalloped hammerhead shark inhabits warm temperate and tropical waters (Maguire et al. 2006; Miller et al. 2014; NMFS 2015e). It occurs in coastal pelagic and estuarine water, but is also known to inhabit open water over continental and insular shelves, as well as deeper waters, with depths up to 1000 m (Miller et al. 2014; NMFS 2015e). Reproduction occurs annually, with a gestation time of 9–12 months (Kotas 2005). Females move inshore to give birth to litters of 1–41 pups (Miller et al. 2014). The scalloped hammerhead shark is very mobile and partly migratory (Maguire et al. 2006), traveling <100 km to >1900 km between aggregations of food sources, eventually returning to its original habitat, displaying site fidelity (Miller et al. 2014). Juveniles and adults can be solitary or travel in pairs; they also school in productive regions, such as over seamounts or near islands (Miller et al. 2014).

#### 3.6.2 Argentine Angelshark (*Squatina argentina*)

The Argentine angelshark is a temperate and subtropical species endemic to South America, where it occurs from Brazil to Argentina (Compagno 1984b). It is a poorly known but moderately common species in coastal waters (Chiaramonte 2005a). It is a demersal shark that inhabits the continental shelf and slope waters (Compagno 1984b), typically occurring at depths of 120–320 m (Vooren and da Silva 1991 in Chiaramonte 2005a). Most females carry 9–10 young (Chiaramonte 2005a).

### 3.6.3 Angular Angelshark (*Squatina guggenheim*)

The angular angelshark is a marine and brackish demersal species endemic to the southwest Atlantic (Vögler et al. 2003). In coastal waters of southern Brazil, it primarily inhabits water 10–80 m deep (Vooren and Da Silva 1991 *in* Chiaramonte 2005b), and off Argentina, it occurs from the coast to depths of 150 m (Gosztonyi 1981 *in* Chiaramonte 2005b). This species has a 3-year reproductive cycle, with a gestation period of 10–12 months and oocyte maturation taking 2 years (Colonello et al. 2007). Females migrate from deeper seas to shallow, inshore nursery grounds to give birth to 2–8 pups that are born in November or December (Colonello et al. 2007). The angular angelshark's low fecundity could result in low productivity (Cousseau 1973 *in* Colonello et al. 2007), which may be the root cause of the drastic fisheries-induced decline in abundance in the southwest Atlantic (Miranda and Vooren 2003 *in* Colonello et al. 2007).

### 3.6.4 Common Thresher Shark (*Alopias vulpinus*)

The common thresher shark is a cosmopolitan species that is found in temperate, subtropical, and tropical waters, but it is most common in temperate waters (Compagno 2001). It mainly inhabits coastal areas, from the surface to depths of up to 366 m, but it can also occur in oceanic areas (Compagno 2001). Nursery areas apparently are found primarily nearshore in temperate waters (Compagno 2001). Females have litters of 2–7 young that are born in spring after a gestation period of ~9 months (Compagno 2001). Young thresher sharks typically remain inshore and in shallow bays (Compagno 2001).

### 3.6.5 Porbeagle Shark (*Lamna nasus*)

The porbeagle shark inhabits coastal and oceanic waters in temperate regions of the Northern and Southern hemispheres (Compagno 2001). The porbeagle shark is a littoral and epipelagic species that primarily occurs on continental offshore fishing banks, but it is also found in oceanic basins and nearshore waters; its depth range is from <1 m to at least 700 m (Compagno 2001). It can occur inshore and near the surface during summer, but it tends to remain offshore, beneath the surface during winter. Some populations, such as in the western North Atlantic, are highly migratory, typically traveling thousands of kilometres along continental shelves (Compagno 2001). Litter size is 1–5 pups (usually 4) with pups born from April to September in the Southern Hemisphere (Compagno 2001). Reproduction is annual with a 8–9 month gestation period (Stevens 2005).

### 3.6.6 Narrownose Smooth-hound Shark (*Mustelus schmitti*)

The narrownose smooth-hound shark is a marine demersal species that is endemic to the western South Atlantic, occurring from Brazil to Argentina (Compagno 1984a). It typically occurs over the continental shelf in water 60–195 m deep (Compagno 1984a). It undergoes annual migrations, typically occupying coastal areas between spring and summer and offshore areas during fall and winter, although it can be found both inshore and offshore throughout the year (Oddone et al. 2007). Reproduction typically occurs in coastal areas (Oddone et al. 2007). Litters are produced once annually and consist of 1–10 pups (Souto 1986 *in* Oddone et al. 2005).

### 3.6.7 Brazilian Guitarfish (*Rhinobatos horkelii*)

The Brazilian guitarfish is a marine demersal species endemic to Brazil (Amaral and Jablonksi 2005). Adults occur in shallow water (<20 m) from November to March to breed and pup, after which time they move into deeper water (>40 m) over the shelf (Lessa and Vooren 2005). Juveniles occur in

shallow water throughout the year. Gestation is 11–12 months, reproduction occurs annually, and females give birth to 4–12 pups by March, with litter size positively correlated with the size of the mother (Lessa and Vooren 2005). This species is known to undertake seasonal migrations (Lessa et al. 1986 in Lessa and Vooren 2005). Because of heavy fishing activity in coastal areas where it breeds and pups, it is likely that the Brazilian guitarfish could be threatened with extinction in the near future (Lessa and Vooren 2005).

### 3.7 Fisheries

High seas, deep-sea fisheries such as those that occur near the proposed survey area are beyond the control of any one State, and as such are entirely dependent on “the willingness of flag States and vessel operators to adopt sustainable and responsible management systems” (FAO 2015a). The legal framework for the governance of high-seas fisheries constitutes the 1982 United Nations Convention for the Law of the Sea (UNCLOS) and other international binding and non-binding agreements (FAO 2015a). To assist member countries in addressing management challenges for deep-sea fisheries, the Food and Agriculture Organization (FAO) in the U.S. developed the *International Guidelines for the Management of Deep-Sea Fisheries in the High Seas* (FAO 2009), a “voluntary international instrument intended to support States and Regional Fisheries Management Organizations (RFMOs) in formulating and implementing appropriate measures for the sustainable management of deep-sea fisheries in the high seas” (FAO 2015a).

Most of the proposed survey area is situated within the SEAFO Convention Area (see § 3.2, above). Also, the proposed survey area overlaps SEAFO VME Closed Area ‘Unnamed Number 15’, which is closed to bottom contact fishing gear (SEAFO 2014c). SEAFO encompasses FAO Southeast Atlantic Fishing (‘Statistical’) Area 47 and a portion of Eastern Central Atlantic Area 34 (Bensch et al. 2009). SEAFO manages commercial fisheries in the SEAFO Convention Area in accordance with a Total Allowable Catch (TAC) system (SEAFO 2014d). At least as of 2009, there is no equivalent organization in the southwest Atlantic region (Bensch et al. 2009).

The proposed survey area is located within FAO Area 47 and Southwest Atlantic Fishing Area 41. The 2008–2012 commercial fisheries information described below for Area 47, which includes most of the proposed survey area, is from all water depths in the following fishing subareas: SEAFO Division C.0, “Tunas” (Atlantic Southeast area), “Southern Oceanic”, and “Not Known” (Atlantic Southeast area) (FAO 2014a). The 2008–2012 commercial fisheries information described below for Area 41, which includes the westernmost portion of the proposed survey area, is also from all water depths; data were not further segregated into subareas for the southwest Atlantic (FAO 2014b). The 2002–2006 southwest and southeast Atlantic information from the Sea Around Us Project (SAUP 2011a,b) also includes all water depths.

The predominant species caught in the southeast Atlantic during 2002–2006 and 2008–2012 include albacore, bigeye, and yellowfin tunas *Thunnus alalunga*, *T. obesus*, and *T. albacares*, cape hakes *Merluccius* sp., swordfish *Xiphias gladius*, Cape Hope squid *Loligo reynaudii*, and blue shark *Prionace glauca* (SAUP 2011a; FAO 2014a; EOL 2015). Other commercially important species in the area include orange roughy *Hoplostethus atlanticus*, alfonsoino *Beryx* spp., Cape horse mackerel *Trachurus capensis* (most predominant commercial species during 2002–2006; SAUP 2011a), little tunny *Euthynnus alletteratus*, shark/skate/ray spp., southern argenti tuna *Thunnus maccoyii*, Atlantic bonito *Sarda sarda*, snoek *Thyrssites atun*, panga seabream *Pterogymnus laniarius*, West African Spanish mackerel *Scomberomorus tritor*, Tristan da Cunha rock lobster *Jasus tristani*, deep-sea red crabs *Geryon* spp., Patagonian toothfish *Dissostichus eleginoides*, pelagic armourhead *Pseudopentaceros richardsoni*,

bluenose warehou *Hyperoglyphe regentines*, boarfishes (notably southern boarfish *Pseudopentaceros richardsoni*), cardinal fishes, octopus sp., oreo dories, and wreckfish *Polyprion americanus* (Garibaldi and Limongelli 2002; Bensch et al. 2009; SAUP 2011a; FAO 2014a; SEAFO 2014e; EOL 2015). The total annual average commercial harvests in the southeast Atlantic were 168,149 t during 2002–2006 and 71,283 t during 2008–2012 (SAUP 2011a; FAO 2014a).

The predominant species caught in the southwest Atlantic during 2002–2006 and 2008–2012 include Argentine shortfin squid *Illex regentines*, Argentine hake *Merluccius hubbsi*, Patagonian grenadier *Macruronus magellanicus*, whitemouth croaker *Micropogonias furnieri*, and Brazilian sardinella *Sardinella brasiliensis* (Bensch et al. 2009; SAUP 2011b; FAO 2014b; EOL 2015). Other notable species include southern blue whiting *Micromesistius australis*, Argentine red shrimp *Pleoticus muelleri*, Patagonian toothfish *Dissostichus eleginoides*, Patagonian scallop *Zygochlamys patagonica*, Patagonian squid *Loligo gahi*, Antarctic rock cods (Nototheniidae), ray/stingray/manta spp., longtail southern cod *Patagonotothen ramsayi*, forkbeard *Phycis phycis*, pink cusk eel *Genypterus blacodes*, southern hake *Merluccius australis*, and sea catfish spp. (Garibaldi and Limongelli 2002; Bensch et al. 2009; SAUP 2011b; FAO 2014b; EOL 2015). The total annual average commercial harvests in the southwest Atlantic were 538,455 t during 2002–2006 and 1,944,641 t during 2008–2012 (SAUP 2011b; FAO 2014b).

The majority of catch in the southeast Atlantic during 2008–2012 was taken by South Africa (32% of total average catch), Taiwan (20%), Japan (17%), and Spain (13%), followed by Angola, Namibia, Republic of Korea, Saint Helena, and China (FAO 2014a). During 2002–2006, commercial catch was predominantly taken by Namibia (54%), South Africa (17%), and Japan (10%), followed by Taiwan, Spain and Angola (SAUP 2011a). The majority of catch in the southwest Atlantic during 2008–2012 was taken by Argentina (42%) and Brazil (29%), followed by Spain, Taiwan, Uruguay, Republic of Korea, Falkland Islands, and China (FAO 2014b). During 2002–2006, the majority of catch was captured by South Korea (21%), Taiwan (18%), China (13%), Argentina (12%), and Brazil (11%), followed by Spain, Uruguay, Japan, and “Others” (SAUP 2011b). Numerous other countries also partook in the fisheries; they are not listed here as they each contributed <0.5% to the total average catch (FAO 2014a,b).

In the southeast Atlantic, orange roughy and alfonso fisheries are conducted using mid-water and bottom trawls (Bensch et al. 2009). Various pelagic fishes are taken as bycatch in these fisheries, including armourhead, oreo, and cardinal fish (Bensch et al. 2009). The Patagonian toothfish is harvested using longlines, and deep-sea red crabs are taken using pots (Bensch et al. 2009). Most (58%) of the catch in the southeast Atlantic was harvested using mid-water trawls, followed by longlines for tuna, gillnets, pole lines for tuna, purse seines, bottom trawls, hooks/gorges, troll lines, and purse seines for tuna (SAUP 2011a). In the southwest Atlantic, trawl fisheries target species such as Argentine hake and Argentine shortfin squid, whereas bottom longlines are used to harvest species such as Patagonian toothfish, Patagonian squid, forkbeard, Patagonian grenadier, pink cusk eel, longtail southern cod, Antarctic rockcods, southern blue whiting, and southern hake (Bensch et al. 2009). Gillnets can also be used in the commercial fisheries in the region, at least within the Brazilian Exclusive Economic Zone (FAO 2015b). Most (66%) catch in the southwest Atlantic was taken using bottom trawls during 2002–2006; by decreasing importance, other important gear included gillnets, mid-water trawls, longlines for tuna, hooks/gorges, and pole lines for tuna (SAUP 2011b).

## IV ENVIRONMENTAL CONSEQUENCES

### 4.1 Proposed Action

#### 4.1.1 Direct Effects on Marine Mammals and Sea Turtles and Their Significance

The material in this section includes a brief summary of the expected potential effects (or lack thereof) of airgun sounds on marine mammals and sea turtles given in the PEIS, and reference to recent literature that has become available since the PEIS was released in 2011. A more comprehensive review of the relevant background information, as well as information on the hearing abilities of marine mammals and sea turtles, appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.

This section also includes estimates of the numbers of marine mammals that could be affected by the proposed seismic survey. A description of the rationale for NSF's estimates of the numbers of individuals exposed to received sound levels  $\geq 160$  dB re 1  $\mu\text{Pa}_{\text{rms}}$  is also provided. Acoustic modeling for the proposed action was conducted by L-DEO, consistent with past EAs and determined to be acceptable by NMFS for use in the calculation of estimated takes under the MMPA (e.g., NMFS 2013a,b).

##### 4.1.1.1 Summary of Potential Effects of Airgun Sounds

As noted in the PEIS (§ 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3), the effects of sounds from airguns could include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical or physiological effects (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007). In some cases, a behavioral response to a sound can reduce the overall exposure to that sound (e.g., Finneran et al. 2015; Wensveen et al. 2015).

Permanent hearing impairment (PTS), in the unlikely event that it occurred, would constitute injury, but temporary threshold shift (TTS) is not considered an injury (Southall et al. 2007; Le Prell 2012). Rather, the onset of TTS has been considered an indicator that, if the animal is exposed to higher levels of that sound, physical damage is ultimately a possibility. Nonetheless, recent research has shown that sound exposure can cause cochlear neural degeneration, even when threshold shifts and hair cell damage are reversible (Liberman 2013). These findings have raised some doubts as to whether TTS should continue to be considered a non-injurious effect (Weilgart 2014; Tougaard et al. 2015). Although the possibility cannot be entirely excluded, it is unlikely that the proposed survey would result in any cases of temporary or permanent hearing impairment, or any significant non-auditory physical or physiological effects. If marine mammals encounter the survey while it is underway, some behavioral disturbance could result, but this would be localized and short-term.

**Tolerance.**—Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers (e.g., Nieuwkirk et al. 2012). Several studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen and toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. The relative responsiveness of baleen and toothed whales are quite variable.

**Masking.**—Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are few specific data on this. Because of the intermittent nature and low duty cycle of seismic pulses, animals can emit and receive sounds in the relatively quiet intervals between pulses. However, in exceptional situations, reverberation occurs for much or all of the interval between pulses (e.g., Simard et al. 2005; Clark and Gagnon 2006), which could mask calls. Situations with prolonged strong reverberation are infrequent. However, it is common for reverberation to cause some lesser degree of elevation of the background level between airgun pulses (e.g., Gedamke 2011; Guerra et al. 2011, 2013; Klinck et al. 2012; Guan et al. 2015), and this weaker reverberation presumably reduces the detection range of calls and other natural sounds to some degree. Guerra et al. (2013) reported that ambient noise levels between seismic pulses were elevated as a result of reverberation at ranges of 50 km from the seismic source. Based on measurements in deep water of the Southern Ocean, Gedamke (2011) estimated that the slight elevation of background levels during intervals between pulses reduced blue and fin whale communication space by as much as 36–51% when a seismic survey was operating 450–2800 km away. Based on preliminary modeling, Wittekind et al. (2013) reported that airgun sounds could reduce the communication range of blue and fin whales 2000 km from the seismic source. Nieukirk et al. (2012) and Blackwell et al. (2013) noted the potential for masking effects from seismic surveys on large whales.

Some baleen and toothed whales are known to continue calling in the presence of seismic pulses, and their calls usually can be heard between the pulses (e.g., Nieukirk et al. 2012; Broker et al. 2013). Cerchio et al. (2014) suggested that the breeding display of humpback whales off Angola could be disrupted by seismic sounds, as singing activity declined with increasing received levels. In addition, some cetaceans are known to change their calling rates, shift their peak frequencies, or otherwise modify their vocal behavior in response to airgun sounds (e.g., Di Iorio and Clark 2010; Castellote et al. 2012; Blackwell et al. 2013, 2015). The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small odontocetes that have been studied directly (e.g., MacGillivray et al. 2014). The sounds important to small odontocetes are predominantly at much higher frequencies than are the dominant components of airgun sounds, thus limiting the potential for masking. In general, masking effects of seismic pulses are expected to be minor, given the normally intermittent nature of seismic pulses. We are not aware of any information concerning masking of hearing in sea turtles.

**Disturbance Reactions.**—Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, and displacement. Based on NMFS (2001, p. 9293), National Research Council (NRC 2005), and Southall et al. (2007), we believe that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or “taking”. By potentially significant, we mean, ‘in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations’.

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors (Richardson et al. 1995; Wartzok et al. 2004; Southall et al. 2007; Weilgart 2007; Ellison et al. 2012). If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or population (e.g., New et al. 2013). However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant (Lusseau and Bejder 2007; Weilgart 2007; Nowacek et al. 2015). Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many marine mammals would be present within a particular distance of industrial activities and/or exposed to a particular level of industrial

sound. In most cases, this approach likely overestimates the numbers of marine mammals that would be affected in some biologically important manner.

The sound criteria used to estimate how many marine mammals could be disturbed to some biologically important degree by a seismic program are based primarily on behavioral observations of a few species. Detailed studies have been done on humpback, gray, bowhead, and sperm whales. Less detailed data are available for some other species of baleen whales and small toothed whales, but for many species, there are no data on responses to marine seismic surveys.

#### *Baleen Whales*

Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. In the cases of migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Responses of *humpback whales* to seismic surveys have been studied during migration, on summer feeding grounds, and on Angolan winter breeding grounds; there has also been discussion of effects on the Brazilian wintering grounds. Off Western Australia, avoidance reactions began at 5–8 km from the array, and those reactions kept most pods ~3–4 km from the operating seismic boat; there was localized displacement during migration of 4–5 km by traveling pods and 7–12 km by more sensitive resting pods of cow-calf pairs (McCauley et al. 1998, 2000). However, some individual humpback whales, especially males, approached within distances of 100–400 m. Studies examining the behavioral responses of humpback whales to airguns are currently underway off eastern Australia (Cato et al. 2011, 2012, 2013).

In the northwest Atlantic, sighting rates were significantly greater during non-seismic periods compared with periods when a full array was operating, and humpback whales were more likely to swim away and less likely to swim towards a vessel during seismic vs. non-seismic periods (Moulton and Holst 2010). In contrast, sightings of humpback whales from seismic vessels off the U.K. during 1994–2010 indicated that detection rates were similar during seismic and non-seismic periods, although sample sizes were small (Stone 2015). On their summer feeding grounds in southeast Alaska, there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1  $\mu$ Pa on an approximate rms basis (Malme et al. 1985). It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004), but data from subsequent years indicated that there was no observable direct correlation between strandings and seismic surveys (IWC 2007).

There are no data on reactions of *right whales* to seismic surveys. However, Rolland et al. (2012) suggested that ship noise causes increased stress in right whales; they showed that baseline levels of stress-related faecal hormone metabolites decreased in North Atlantic right whales with a 6-dB decrease in underwater noise from vessels. Wright et al. (2011) and Atkinson et al. (2015) also reported that sound could be a potential source of stress for marine mammals.

*Bowhead whales* show that their responsiveness can be quite variable depending on their activity (migrating vs. feeding). Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in

particular, are unusually responsive, with substantial avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). Subtle but statistically significant changes in surfacing–respiration–dive cycles were shown by traveling and socializing bowheads exposed to airgun sounds in the Beaufort Sea, including shorter surfacings, shorter dives, and decreased number of blows per surfacing (Robertson et al. 2013). More recent research on bowhead whales corroborates earlier evidence that, during the summer feeding season, bowheads are less responsive to seismic sources (e.g., Miller et al. 2005; Robertson et al. 2013).

Bowhead whale calls detected in the presence and absence of airgun sounds have been studied extensively in the Beaufort Sea. Bowheads continue to produce calls of the usual types when exposed to airgun sounds on their summering grounds, although numbers of calls detected are significantly lower in the presence than in the absence of airgun pulses (Blackwell et al. 2013, 2015). Blackwell et al. (2013) reported that calling rates in 2007 declined significantly where received SPLs from airgun sounds were 116–129 dB re 1  $\mu\text{Pa}$ ; at SPLs <108 dB re 1  $\mu\text{Pa}$ , calling rates were not affected. When data for 2007–2010 were analyzed, Blackwell et al. (2015) reported an initial increase in calling rates when airgun pulses became detectable; however, calling rates leveled off at a received CSEL<sub>10-min</sub> (cumulative SEL over a 10-min period) of ~94 dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$ , decreased at CSEL<sub>10-min</sub> >127 dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$ , and whales were nearly silent at CSEL<sub>10-min</sub> >160 dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$ . Thus, bowhead whales in the Beaufort Sea apparently decreased their calling rates in response to seismic operations, although movement out of the area could also have contributed to the lower call detection rate (Blackwell et al. 2013, 2015).

A multivariate analysis of factors affecting the distribution of calling bowhead whales during their fall migration in 2009 noted that the southern edge of the distribution of calling whales was significantly closer to shore with increasing levels of airgun sound from a seismic survey a few hundred kilometers to the east of the study area (i.e., behind the westward-migrating whales; McDonald et al. 2010, 2011). It was not known whether this statistical effect represented a stronger tendency for quieting of the whales farther offshore in deeper water upon exposure to airgun sound, or an actual inshore displacement of whales.

Reactions of migrating and feeding (but not wintering) *gray whales* to seismic surveys have been studied. Off St. Lawrence Island in the northern Bering Sea, it was estimated, based on small sample sizes, that 50% of feeding gray whales stopped feeding at an average received pressure level of 173 dB re 1  $\mu\text{Pa}$  on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB re 1  $\mu\text{Pa}_{\text{rms}}$  (Malme et al. 1986, 1988). Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast (Malme et al. 1984; Malme and Miles 1985) and western Pacific gray whales feeding off Sakhalin Island, Russia (e.g., Gailey et al. 2007; Johnson et al. 2007; Yazvenko et al. 2007a,b).

Various species of *Balaenoptera* (blue, sei, fin, and minke whales) have occasionally been seen in areas ensounded by airgun pulses. Sightings by observers on seismic vessels using large arrays off the U.K. from 1994 to 2010 showed that the detection rate for minke whales was significantly higher when airguns were not operating; however, during surveys with small arrays, the detection rates for minke whales were similar during seismic and non-seismic periods (Stone 2015). Sighting rates for fin and sei whales were similar when large arrays of airguns were operating vs. silent. All baleen whales combined tended to exhibit localized avoidance, remaining significantly farther (on average) from large arrays (median closest point of approach or CPA of ~1.5 km) during seismic operations compared with non-seismic periods (median CPA ~1.0 km). In addition, fin and minke whales were more often oriented away from the vessel while a large airgun array was active compared with periods of inactivity. Singing

fin whales in the Mediterranean moved away from an operating airgun array, and their song notes had lower bandwidths during periods with vs. without airgun sounds (Castellote et al. 2012).

During seismic surveys in the northwest Atlantic, baleen whales as a group showed localized avoidance of the operating array (Moulton and Holst 2010). Sighting rates were significantly lower during seismic operations compared with non-seismic periods. Baleen whales were seen on average 200 m farther from the vessel during airgun activities vs. non-seismic periods, and these whales more often swam away from the vessel when seismic operations were underway compared with periods when no airguns were operating. Blue whales were seen significantly farther from the vessel during single airgun operations, ramp up, and all other airgun operations compared with non-seismic periods. Similarly, fin whales were seen at significantly farther distances during ramp up than during periods without airgun operations; there was also a trend for fin whales to be sighted farther from the vessel during other airgun operations, but the difference was not significant. Minke whales were seen significantly farther from the vessel during periods with than without seismic operations. Minke whales were also more likely to swim away and less likely to approach during seismic operations compared to periods when airguns were not operating.

Data on short-term reactions by cetaceans to impulsive noises are not necessarily indicative of long-term or biologically significant effects. It is not known whether impulsive sounds affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales have continued to migrate annually along the west coast of North America with substantial increases in the population over recent years, despite intermittent seismic exploration (and much ship traffic) in that area for decades. The western Pacific gray whale population did not seem affected by a seismic survey in its feeding ground during a previous year, and bowhead whales have continued to travel to the eastern Beaufort Sea each summer, and their numbers have increased notably, despite seismic exploration in their summer and autumn range for many years.

#### *Toothed Whales*

Little systematic information is available about reactions of toothed whales to sound pulses. However, there are recent systematic studies on sperm whales, and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies. Seismic operators and marine mammal observers on seismic vessels regularly see dolphins and other small toothed whales near operating airgun arrays, but in general there is a tendency for most delphinids to show some avoidance of operating seismic vessels (e.g., Stone and Tasker 2006; Moulton and Holst 2010; Barry et al. 2012; Wole and Myade 2014; Stone 2015). In most cases, the avoidance radii for delphinids appear to be small, on the order of 1 km or less, and some individuals show no apparent avoidance.

Observations from seismic vessels using large arrays off the U.K. from 1994 to 2010 indicated that detection rates were significantly higher for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins when airguns were not operating; detection rates during seismic vs. non-seismic periods were similar during seismic surveys using small arrays (Stone 2015). Detection rates for long-finned pilot whales, Risso's dolphins, bottlenose dolphins, and short-beaked common dolphins were similar during seismic (small or large array) vs. non-seismic operations. CPA distances for killer whales, white-beaked dolphins, and Atlantic white-sided dolphins were significantly farther (>0.5 km) from large airgun arrays during periods of airgun activity compared with periods of inactivity, with significantly more animals traveling away from the vessel during airgun operation. Observers' records suggested that fewer

cetaceans were feeding and fewer delphinids were interacting with the survey vessel (e.g., bow-riding) during periods with airguns operating.

During seismic surveys in the northwest Atlantic, delphinids as a group showed some localized avoidance of the operating array (Moulton and Holst 2010). The mean initial detection distance was significantly farther (by ~200 m) during seismic operations compared with periods when the seismic source was not active; however, there was no significant difference between sighting rates. The same results were evident when only long-finned pilot whales were considered.

Preliminary findings of a monitoring study of *narwhals* in Melville Bay, Greenland (summer and fall 2012) showed no short-term effects of seismic survey activity on narwhal distribution, abundance, migration timing, and feeding habits (Heide-Jørgensen et al. 2013a). In addition, there were no reported effects on narwhal hunting. These findings do not seemingly support a suggestion by Heide-Jørgensen et al. (2013b) that seismic surveys in Baffin Bay may have delayed the migration timing of narwhals, thereby increasing the risk of narwhals to ice entrapment.

The beluga, however, is a species that (at least at times) shows long-distance (10s of km) avoidance of seismic vessels (e.g., Miller et al. 2005). Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys, but the animals tolerated high received levels of sound before exhibiting aversive behaviors (e.g., Finneran et al. 2000, 2002, 2005).

Most studies of *sperm whales* exposed to airgun sounds indicate that the sperm whale shows considerable tolerance of airgun pulses; in most cases the whales do not show strong avoidance (e.g., Stone and Tasker 2006; Moulton and Holst 2010), but foraging behavior can be altered upon exposure to airgun sound (e.g., Miller et al. 2009). Based on data collected by observers on seismic vessels off the U.K. from 1994 to 2010, detection rates for sperm whales were similar when large arrays of airguns were operating vs. silent; however, during surveys with small arrays, the detection rate was significantly higher when the airguns were not in operation (Stone 2015). Preliminary data from the Gulf of Mexico show a correlation between reduced sperm whale acoustic activity during periods with airgun operations (Sidorovskaia et al. 2014).

There are almost no specific data on the behavioral reactions of *beaked whales* to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998) and/or change their behavior in response to sounds from vessels (e.g., Pirota et al. 2012). Thus, it is likely that most beaked whales would also show strong avoidance of an approaching seismic vessel. Observations from seismic vessels off the U.K. from 1994 to 2010 indicated that detection rates of beaked whales were significantly higher ( $p < 0.05$ ) when airguns were not operating vs. when a large array was in operation, although sample sizes were small (Stone 2015). Some northern bottlenose whales remained in the general area and continued to produce high-frequency clicks when exposed to sound pulses from distant seismic surveys (e.g., Simard et al. 2005).

The limited available data suggest that *harbor porpoises* show stronger avoidance of seismic operations than do Dall's porpoises. Based on data collected by observers on seismic vessels off the U.K. from 1994 to 2010, detection rates of harbor porpoises were significantly higher when airguns were silent vs. when large or small arrays were operating (Stone 2015). In addition, harbor porpoises were seen farther away from the array when it was operating vs. silent, and were most often seen traveling away from the airgun array when it was in operation (Stone 2015). Thompson et al. (2013) reported decreased densities and reduced acoustic detections of harbor porpoise in response to a seismic survey in Moray Firth, Scotland, at ranges of 5–10 km (SPLs of 165–172 dB re 1  $\mu$ Pa, SELs of 145–151 dB  $\mu$ Pa<sup>2</sup>·s). For

the same survey, Pirotta et al. (2014) reported that the probability of recording a porpoise buzz decreased by 15% in the ensonified area, and that the probability was positively related to the distance from the seismic ship; the decreased buzzing occurrence may indicate reduced foraging efficiency. Nonetheless, animals returned to the area within a few hours (Thompson et al. 2013). Kastelein et al. (2013a) reported that a harbor porpoise showed no response to an impulse sound with an SEL below 65 dB, but a 50% brief response rate was noted at an SEL of 92 dB and an SPL of 122 dB re 1  $\mu\text{Pa}_{0\text{-peak}}$ . The apparent tendency for greater responsiveness in the harbor porpoise is consistent with its relative responsiveness to boat traffic and some other acoustic sources (Richardson et al. 1995; Southall et al. 2007).

Odontocete reactions to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for the more responsive of the mysticetes and some other odontocetes. A  $\geq 170$  dB disturbance criterion (rather than  $\geq 160$  dB) is considered appropriate for delphinids, which tend to be less responsive than the more responsive cetaceans.

#### *Pinnipeds*

Pinnipeds are not likely to show a strong avoidance reaction to an airgun array. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds and only slight (if any) changes in behavior. However, telemetry work has suggested that avoidance and other behavioral reactions may be stronger than evident to date from visual studies (Thompson et al. 1998). Observations from seismic vessels operating large arrays off the U.K. from 1994 to 2010 showed that the detection rate for grey seals was significantly higher when airguns were not operating; for surveys using small arrays, the detection rates were similar during seismic vs. non-seismic operations (Stone 2015). No significant differences in detection rates were apparent for harbor seals during seismic and non-seismic periods (Stone 2015). There were no significant differences in CPA distances of grey or harbor seals during seismic vs. non-seismic periods (Stone 2015).

#### *Sea Turtles*

Several recent papers discuss the morphology of the turtle ear (e.g., Christensen-Dalsgaard et al. 2012; Willis et al. 2013) and the hearing ability of sea turtles (e.g., Martin et al. 2012; Piniak et al. 2012a,b; Lavender et al. 2014). The limited available data indicate that sea turtles will hear airgun sounds and sometimes exhibit localized avoidance (see PEIS, § 3.4.4.3).

DeRuiter and Doukara (2012) observed that immediately following an airgun pulse, small numbers of basking loggerhead turtles (6 of 86 turtles observed) exhibited an apparent startle response (sudden raising of the head and splashing of flippers, occasionally accompanied by blowing bubbles from the beak and nostrils, followed by a short dive). Diving turtles (49 of 86 individuals) were observed at distances from the center of the airgun array ranging from 50 to 839 m. The estimated sound level at the median distance of 130 m was 191 dB re 1  $\mu\text{Pa}_{\text{peak}}$ . These observations were made during ~150 h of vessel-based monitoring from a seismic vessel operating an airgun array (13 airguns, 2440 in<sup>3</sup>) off Algeria; there was no corresponding observation effort during periods when the airgun array was inactive (DeRuiter and Doukara 2012).

Based on available data, it is likely that sea turtles will exhibit behavioral changes and/or avoidance within an area of unknown size near a seismic vessel. To the extent that there are any impacts on sea turtles, seismic operations in or near areas where turtles concentrate would likely have the greatest impact; concentration areas are not known to occur within the proposed survey area. There are no specific data that demonstrate the consequences to sea turtles if seismic operations with large or small arrays of airguns occur in important areas at biologically important times of the year.

**Hearing Impairment and Other Physical Effects.**—Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. TTS has been demonstrated and studied in certain captive odontocetes and pinnipeds exposed to strong sounds (see review by Finneran 2015). However, there has been no specific documentation of TTS let alone permanent hearing damage, i.e., PTS, in free-ranging marine mammals exposed to sequences of airgun pulses during realistic field conditions.

Additional data are needed to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. To determine how close an airgun array would need to approach in order to elicit TTS, one would (as a minimum) need to allow for the sequence of distances at which airgun pulses would occur, and for the dependence of received SEL on distance in the region of the seismic operation (e.g., Breitzke and Bohlen 2010; Laws 2012). At the present state of knowledge, it is also necessary to assume that the effect is directly related to total received energy (SEL); however, this assumption is likely an over-simplification (Finneran 2012). There is recent evidence that auditory effects in a given animal are not a simple function of received acoustic energy (Finneran 2015). Frequency, duration of the exposure, and occurrence of gaps within the exposure can also influence the auditory effect (Finneran and Schlundt 2010, 2011, 2013; Finneran et al. 2010a,b; Popov et al. 2011, 2013a; Finneran 2012, 2015; Kastelein et al. 2012a,b; 2013b,c, 2014, 2015a; Ketten 2012).

Recent data have shown that the SEL required for TTS onset to occur increases with intermittent exposures, with some auditory recovery during silent periods between signals (Finneran et al. 2010b; Finneran and Schlundt 2011). Studies on bottlenose dolphins by Finneran et al. (2015) indicate that the potential for seismic surveys using airguns to cause auditory effects on dolphins could be lower than previously thought. Based on behavioral tests, Finneran et al. (2015) reported no measurable TTS in three bottlenose dolphins after exposure to 10 impulses from a seismic airgun with a cumulative SEL of up to  $\sim 195 \text{ dB re } 1 \mu\text{Pa}^2 \cdot \text{s}$ . However, auditory evoked potential measurements were more variable; one dolphin showed a small (9 dB) threshold shift at 8 kHz (Finneran et al. 2015).

Recent studies have also shown that the SEL necessary to elicit TTS can depend substantially on frequency, with susceptibility to TTS increasing with increasing frequency above 3 kHz (Finneran and Schlundt 2010, 2011; Finneran 2012). When beluga whales were exposed to fatiguing noise with sound levels of 165 dB re 1  $\mu\text{Pa}$  for durations of 1–30 min at frequencies of 11.2–90 kHz, the highest TTS with the longest recovery time was produced by the lower frequencies (11.2 and 22.5 kHz); TTS effects also gradually increased with prolonged exposure time (Popov et al. 2013a). Additionally, Popov et al. (2015) demonstrated that the impacts of TTS include deterioration of signal discrimination. Kastelein et al. (2015b) reported that exposure to multiple pulses with most energy at low frequencies can lead to TTS at higher frequencies in some cetaceans, such as the harbor porpoise.

Popov et al. (2013b) reported that TTS produced by exposure to a fatiguing noise was larger during the first session (or naïve subject state) with a beluga whale than TTS that resulted from the same sound in subsequent sessions (experienced subject state). Similarly, several other studies have shown that some marine mammals (e.g., bottlenose dolphins, false killer whales) can decrease their hearing sensitivity in order to mitigate the impacts of exposure to loud sounds (e.g., Nachtigall and Supin 2013, 2014, 2015).

Previous information on TTS for odontocetes was primarily derived from studies on the bottlenose dolphin and beluga, and that for pinnipeds has mostly been obtained from California sea lions and elephant seals (see § 3.6.4.3, § 3.7.4.3, § 3.8.4.3 and Appendix E of the PEIS). Thus, it is inappropriate to assume that onset of TTS occurs at similar received levels in all cetaceans or pinnipeds (*cf.* Southall et al.

2007). Some cetaceans or pinnipeds could incur TTS at lower sound exposures than are necessary to elicit TTS in the beluga and bottlenose dolphin or California sea lion and elephant seal, respectively.

Several studies on TTS in porpoises (e.g., Lucke et al. 2009; Popov et al. 2011; Kastelein et al. 2012a, 2013b,c, 2014, 2015a) indicate that received levels that elicit onset of TTS are lower in porpoises than in other odontocetes. Kastelein et al. (2012a) exposed a harbor porpoise to octave band noise centered at 4 kHz for extended periods of time. A 6-dB TTS occurred with SELs of 163 dB and 172 dB for low-intensity sound and medium-intensity sound, respectively; high-intensity sound caused a 9-dB TTS at a SEL of 175 dB (Kastelein et al. 2012a). Kastelein et al. (2013b) exposed a harbor porpoise to a long, continuous 1.5-kHz tone, which induced a 14-dB TTS with a total SEL of 190 dB. Popov et al. (2011) examined the effects of fatiguing noise on the hearing threshold of Yangtze finless porpoises when exposed to frequencies of 32–128 kHz at 140–160 dB re 1  $\mu$ Pa for 1–30 min. They found that an exposure of higher level and shorter duration produced a higher TTS than an exposure of equal SEL but of lower level and longer duration. Popov et al. (2011) reported a TTS of 25 dB for a Yangtze finless porpoise that was exposed to high levels of 3-min pulses of half-octave band noise centered at 45 kHz with an SEL of 163 dB.

Initial evidence from exposures to non-pulses has also suggested that some pinnipeds (harbor seals in particular) incur TTS at somewhat lower received levels than do most small odontocetes exposed for similar durations (Kastak et al. 1999, 2005, 2008; Ketten et al. 2001). Kastelein et al. (2012b) exposed two harbor seals to octave-band white noise centered at 4 kHz at three mean received SPLs of 124, 136, and 148 dB re 1  $\mu$ Pa; TTS >2.5 dB was induced at an SEL of 170 dB (136 dB SPL for 60 min), and the maximum TTS of 10 dB occurred after a 120-min exposure to 148 dB re 1  $\mu$ Pa or an SEL of 187 dB. Kastelein et al. (2013c) reported that a harbor seal unintentionally exposed to the same sound source with a mean received SPL of 163 dB re 1  $\mu$ Pa for 1 h induced a 44 dB TTS. For a harbor seal exposed to octave-band white noise centered at 4 kHz for 60 min with mean SPLs of 124–148 re 1  $\mu$ Pa, the onset of PTS would require a level of at least 22 dB above the TTS onset (Kastelein et al. 2013c).

Based on the best available information at the time, Southall et al. (2007) recommended a TTS threshold for exposure to single or multiple pulses of 183 dB re 1  $\mu$ Pa<sup>2</sup> · s for all cetaceans and 173 dB re 1  $\mu$ Pa<sup>2</sup> · s for pinnipeds in water. For the harbor porpoise, Tougaard et al. (2015) have suggested an exposure limit for TTS as an SEL of 100–110 dB above the pure tone hearing threshold at a specific frequency; they also suggested an exposure limit of  $L_{eq-fast}$  (rms average over the duration of the pulse) of 45 dB above the hearing threshold for behavioral responses (i.e., negative phonotaxis). In addition, M-weighting, as used by Southall et al. (2007), might not be appropriate for the harbor porpoise (Wensveen et al. 2014; Tougaard et al. 2015); thus, Wensveen et al. (2014) developed six auditory weighting functions for the harbor porpoise that could be useful in predicting TTS onset. Gedamke et al. (2011), based on preliminary simulation modeling that attempted to allow for various uncertainties in assumptions and variability around population means, suggested that some baleen whales whose closest point of approach to a seismic vessel is 1 km or more could experience TTS.

Hermannsen et al. (2015) reported that there is little risk of hearing damage to harbor seals or harbor porpoises, which are thought to incur TTS at lower received levels than do most small odontocetes, when using single airguns in shallow water. Similarly, it is unlikely that a marine mammal would remain close enough to a large airgun array for sufficiently long to incur TTS, let alone PTS. There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that some mammals close to an airgun array might incur at least mild TTS, there has been further speculation about the possibility that some

individuals occurring very close to airguns might incur PTS (e.g., Richardson et al. 1995, p. 372ff; Gedamke et al. 2011). In terrestrial animals, exposure to sounds sufficiently strong to elicit a large TTS induces physiological and structural changes in the inner ear, and at some high level of sound exposure, these phenomena become non-recoverable (Le Prell 2012). At this level of sound exposure, TTS grades into PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage, but repeated or (in some cases) single exposures to a level well above that causing TTS onset might elicit PTS (e.g., Kastak and Reichmuth 2007; Kastak et al. 2008).

Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds with received levels  $\geq 180$  dB and 190 dB re 1  $\mu\text{Pa}_{\text{rms}}$ , respectively (NMFS 2000). These criteria have been used in establishing the EZs (or shut-down zones) planned for the proposed seismic survey. However, those criteria were established before there was any information about minimum received levels of sounds necessary to cause auditory impairment in marine mammals.

Recommendations for science-based noise exposure criteria for marine mammals, frequency-weighting procedures, and related matters were published by Southall et al. (2007). Those recommendations were never formally adopted by NMFS for use in regulatory processes and during mitigation programs associated with seismic surveys, although some aspects of the recommendations have been taken into account in certain environmental impact statements and small-take authorizations. In July 2015, NOAA made available for a second public comment period new draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2015a), taking at least some of the Southall et al. recommendations into account, as well as more recent literature. At the time of preparation of this Draft EA, the date of release of the final guidelines and how they would be implemented are unknown.

Nowacek et al. (2013) concluded that current scientific data indicate that seismic airguns have a low probability of directly harming marine life, except at close range. Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. Also, many marine mammals and (to a limited degree) sea turtles show some avoidance of the area where received levels of airgun sound are high enough such that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) are especially susceptible to injury and/or stranding when exposed to strong transient sounds.

There is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns. However, Gray and Van Waerebeek (2011) have suggested a cause-effect relationship between a seismic survey off Liberia in 2009 and the erratic movement, postural instability, and akinesia in a pantropical spotted dolphin based on spatially and temporally close association with the airgun array. Additionally, a few cases of strandings in the general area where a seismic survey was ongoing have led to speculation concerning a possible link between seismic surveys and strandings (e.g., Castellote and Llorens 2013).

Non-auditory effects, if they occur at all, would presumably be limited to short distances and to activities that extend over a prolonged period. Marine mammals that show behavioral avoidance of seismic

vessels, including most baleen whales, some odontocetes, and some pinnipeds, are especially unlikely to incur non-auditory physical effects. The brief duration of exposure of any given mammal, the deep water in the study area, and the planned monitoring and mitigation measures would further reduce the probability of exposure of marine mammals to sounds strong enough to induce non-auditory physical effects.

#### *Sea Turtles*

There is substantial overlap in the frequencies that sea turtles detect vs. the frequencies in airgun pulses. We are not aware of measurements of the absolute hearing thresholds of any sea turtle to waterborne sounds similar to airgun pulses. In the absence of relevant absolute threshold data, we cannot estimate how far away an airgun array might be audible. Moein et al. (1994) and Lenhardt (2002) reported TTS for loggerhead turtles exposed to many airgun pulses (see § 3.4.4 of the PEIS). This suggests that sounds from an airgun array might cause temporary hearing impairment in sea turtles if they do not avoid the (unknown) radius where TTS occurs. However, exposure duration during the proposed survey would be much less than during the aforementioned studies. Also, recent monitoring studies show that some sea turtles do show localized movement away from approaching airguns. At short distances from the source, received sound level diminishes rapidly with increasing distance. In that situation, even a small-scale avoidance response could result in a significant reduction in sound exposure.

Although it is possible that exposure to airgun sounds could cause mortality or mortal injuries in sea turtles close to the source, this has not been demonstrated and seems highly unlikely (Popper et al. 2014), especially because sea turtles appear to be highly resistant to explosives (Ketten et al. 2005 in Popper et al. 2014). Nonetheless, Popper et al. (2014) proposed sea turtle mortality/mortal injury criteria of 210 dB SEL or  $>207 \text{ dB}_{\text{peak}}$  for sounds from seismic airguns.

The PSOs stationed on the *Langseth* would watch for sea turtles, and airgun operations would be shut down if a turtle enters the designated EZ.

#### **4.1.1.2 Possible Effects of Other Acoustic Sources**

The Kongsberg EM 122 MBES and Knudsen Chirp 3260 SBP would be operated from the source vessel during the proposed survey. Information about this equipment was provided in § 2.2.3.1 of the PEIS. A review of the expected potential effects (or lack thereof) of MBESs, SBPs, and pingers on marine mammals and sea turtles appears in § 3.4.4.3, § 3.6.4.3, § 3.7.4.3, § 3.8.4.3, and Appendix E of the PEIS.

There has been some recent attention given to the effects of MBES on marine mammals, as a result of a report issued in September 2013 by an IWC independent scientific review panel linking the operation of an MBES to a mass stranding of melon-headed whales (*Peponocephala electra*; Southall et al. 2013) off Madagascar. During May–June 2008, ~100 melon-headed whales entered and stranded in the Loza Lagoon system in northwest Madagascar at the same time that a 12-kHz MBES survey was being conducted ~65 km away off the coast. In conducting a retrospective review of available information on the event, an independent scientific review panel concluded that the Kongsberg EM 120 MBES was the most plausible behavioral trigger for the animals initially entering the lagoon system and eventually stranding. The independent scientific review panel, however, identified that an unequivocal conclusion on causality of the event was not possible because of the lack of information about the event and a number of potentially contributing factors. Additionally, the independent review panel report indicated that this incident was likely the result of a complicated confluence of environmental, social, and other factors that have a very low probability of occurring again in the future, but recommended that the potential be considered in environmental planning. It should be noted that this event is the first known

marine mammal mass stranding closely associated with the operation of an MBES. Leading scientific experts knowledgeable about MBES have expressed concerns about the independent scientific review panel analyses and findings (Bernstein 2013).

Lurton (2015) modeled MBES radiation characteristics (pulse design, source level, and radiation directivity pattern) applied to a low-frequency (12 kHz), 240-dB source-level system like that used on the *Langseth*. Using Southall et al. (2007) thresholds, he found that injury impacts were possible only at very short distances, e.g., at 5 m for maximum SPL and 12 m for cumulative SEL for cetaceans; corresponding distances for behavioural response were 9 m and 70 m. For pinnipeds, “all ranges are multiplied by a factor of 4” (Lurton 2015:209).

There is no available information on marine mammal behavioral response to MBES sounds (Southall et al. 2013) or sea turtle responses to MBES systems. Much of the literature on marine mammal response to sonars relates to the types of sonars used in naval operations, including Low-Frequency Active (LFA) sonars (e.g., Miller et al. 2012; Sivle et al. 2012) and Mid-Frequency Active (MFA) sonars (e.g., Tyack et al. 2011; Melcón et al. 2012; Miller et al. 2012; DeRuiter et al. 2013a,b; Goldbogen et al. 2013; Baird et al. 2014; Wensveen et al. 2015). However, the MBES sounds are quite different from naval sonars. Ping duration of the MBES is very short relative to naval sonars. Also, at any given location, an individual marine mammal would be in the beam of the MBES for much less time given the generally downward orientation of the beam and its narrow fore-aft beamwidth; naval sonars often use near-horizontally-directed sound. In addition, naval sonars have higher duty cycles. These factors would all reduce the sound energy received from the MBES relative to that from naval sonars.

In the fall of 2006, an Ocean Acoustic Waveguide Remote Sensing (OAWRS) experiment was carried out in the Gulf of Maine (Gong et al. 2014); the OAWRS emitted three frequency-modulated (FM) pulses centered at frequencies of 415, 734, and 949 Hz (Risch et al. 2012). Risch et al. (2012) found a reduction in humpback whale song in the Stellwagen Bank National Marine Sanctuary during OAWRS activities that were carried out ~200 km away; received levels in the sanctuary were 88–110 dB re 1  $\mu$ Pa. In contrast, Gong et al. (2014) reported no effect of the OAWRS signals on humpback whale vocalizations in the Gulf of Maine. Range to the source, ambient noise, and/or behavioral state may have differentially influenced the behavioral responses of humpbacks in the two areas (Risch et al. 2014).

Deng et al (2014) measured the spectral properties of pulses transmitted by three 200-kHz echosounders and found that they generated weaker sounds at frequencies below the center frequency (90–130 kHz). These sounds are within the hearing range of some marine mammals, and the authors suggested that they could be strong enough to elicit behavioral responses within close proximity to the sources, although they would be well below potentially harmful levels. Hastie et al. (2014) reported behavioral responses by grey seals to echosounders with frequencies of 200 and 375 kHz.

Despite the aforementioned information that has recently become available, this Draft EA is in agreement with the assessment presented in § 3.4.7, 3.6.7, 3.7.7, and 3.8.7 of the PEIS that operation of MBESs, SBPs, and pingers is not likely to impact marine mammals and is not expected to affect sea turtles, (1) given the lower acoustic exposures relative to airguns and (2) because the intermittent and/or narrow downward-directed nature of these sounds would result in no more than one or two brief ping exposures of any individual marine mammal or sea turtle given the movement and speed of the vessel. Also, for sea turtles, the associated frequency ranges are above their known hearing range.

#### 4.1.1.3 Other Possible Effects of Seismic Surveys

Other possible effects of seismic surveys on marine mammals and/or sea turtles include masking by vessel noise, disturbance by vessel presence or noise, and injury or mortality from collisions with vessels or entanglement in seismic gear.

Vessel noise from the *Langseth* could affect marine animals in the proposed survey area. Sounds produced by large vessels generally dominate ambient noise at frequencies from 20 to 300 Hz (Richardson et al. 1995). However, some energy is also produced at higher frequencies (Hermannsen et al. 2014); low levels of high-frequency sound from vessels has been shown to elicit responses in harbor porpoise (Dyndo et al. 2015). Ship noise, through masking, can reduce the effective communication distance of a marine mammal if the frequency of the sound source is close to that used by the animal, and if the sound is present for a significant fraction of time (e.g., Richardson et al. 1995; Clark et al. 2009; Jensen et al. 2009; Gervaise et al. 2012; Hatch et al. 2012; Rice et al. 2014). In addition to the frequency and duration of the masking sound, the strength, temporal pattern, and location of the introduced sound also play a role in the extent of the masking (Branstetter et al. 2013; Finneran and Branstetter 2013). Branstetter et al. (2013) reported that time-domain metrics are also important in describing and predicting masking. In order to compensate for increased ambient noise, some cetaceans are known to increase the source levels of their calls in the presence of elevated noise levels from shipping, shift their peak frequencies, or otherwise change their vocal behavior (e.g., Parks et al. 2011; 2012; Castellote et al. 2012; Melcón et al. 2012; Tyack and Janik 2013; Luís et al. 2014; Sairanen 2014; Papale et al. 2015). Holt et al. (2015) reported that changes in vocal modifications can have increased energetic costs for individual marine mammals.

Baleen whales are thought to be more sensitive to sound at these low frequencies than are toothed whales (e.g., MacGillivray et al. 2014), possibly causing localized avoidance of the proposed survey area during seismic operations. Reactions of gray and humpback whales to vessels have been studied, and there is limited information available about the reactions of right whales and narwhals (fin, blue, and minke whales). Reactions of humpback whales to boats are variable, ranging from approach to avoidance (Payne 1978; Salden 1993). Baker et al. (1982, 1983) and Baker and Herman (1989) found humpbacks often move away when vessels are within several kilometers. Humpbacks seem less likely to react overtly when actively feeding than when resting or engaged in other activities (Krieger and Wing 1984, 1986).

Many odontocetes show considerable tolerance of vessel traffic, although they sometimes react at long distances if confined by ice or shallow water, if previously harassed by vessels, or have had little or no recent exposure to ships (Richardson et al. 1995). Dolphins of many species tolerate and sometimes approach vessels. Some dolphin species approach moving vessels to ride the bow or stern waves (Williams et al. 1992). Pirotta et al. (2015) noted that the physical presence of vessels, not just ship noise, disturbed the foraging activity of bottlenose dolphins. There are few data on the behavioral reactions of beaked whales to vessel noise, though they seem to avoid approaching vessels (e.g., Würsig et al. 1998) or dive for an extended period when approached by a vessel (e.g., Kasuya 1986). Based on a single observation, Aguilar Soto et al. (2006) suggested that foraging efficiency of Cuvier's beaked whales may be reduced by close approach of vessels.

The PEIS concluded that project vessel sounds would not be at levels expected to cause anything more than possible localized and temporary behavioral changes in marine mammals or sea turtles, and would not be expected to result in significant negative effects on individuals or at the population level. In addition, in all oceans of the world, large vessel traffic is currently so prevalent that it is commonly considered a usual source of ambient sound.

Another concern with vessel traffic is the potential for striking marine mammals or sea turtles. Information on vessel strikes is reviewed in § 3.4.4.4, § 3.6.4.4, and § 3.8.4.4 of the PEIS. The PEIS concluded that the risk of collision of seismic vessels or towed/deployed equipment with marine mammals or sea turtles exists but is extremely unlikely, because of the relatively slow operating speed (typically 7–9 km/h) of the vessel during seismic operations, and the generally straight-line movement of the seismic vessel. There has been no history of marine mammal vessel strikes with the R/V *Langseth*, or its predecessor, R/V *Maurice Ewing* over the last two decades.

Entanglement of sea turtles in seismic gear is also a concern. There have been reports of turtles being trapped and killed between the gaps in tail-buoys offshore from West Africa (Weir 2007b); however, these tailbuoys are significantly different than those used on the *Langseth*. In April 2011, a dead olive ridley turtle was found in a deflector foil of the seismic gear on the *Langseth* during equipment recovery at the conclusion of a survey off Costa Rica, where sea turtles were numerous. Such incidents are possible, but that was the only case of sea turtle entanglement in seismic gear for the *Langseth*, which has been conducting seismic surveys since 2008, or for its predecessor, R/V *Maurice Ewing*, during 2003–2007. Towing the seismic equipment during the proposed survey is not expected to significantly interfere with sea turtle movements, including migration.

#### 4.1.1.4 Mitigation Measures

Several mitigation measures are built into the proposed seismic survey as an integral part of the planned activity. These measures include the following: ramp ups; typically two, however a minimum of one dedicated observer maintaining a visual watch during all daytime airgun operations; two observers for 30 min before and during ramp ups; PAM during the day and night to complement visual monitoring (unless the system and back-up systems are damaged during operations); and power downs (or if necessary shut downs) when mammals or turtles are detected in or about to enter designated EZ. These mitigation measures are described in § 2.4.4.1 of the PEIS and summarized earlier in this document, in § II (2.1.3). The fact that the 36-airgun array, because of its design, would direct the majority of the energy downward, and less energy laterally, is also an inherent mitigation measure.

Previous and subsequent analysis of the potential impacts takes account of these planned mitigation measures. It would not be meaningful to analyze the effects of the planned activity without mitigation, as the mitigation (and associated monitoring) measures are a basic part of the activity, and would be implemented under the Proposed Action or Alternative Action.

#### 4.1.1.5 Potential Numbers of Cetaceans Exposed to Received Sound Levels $\geq 160$ dB

All expected takes would be “takes by harassment” as described in § I, involving temporary changes in behavior. The mitigation measures to be applied would minimize the possibility of injurious takes. (However, as noted earlier and in the PEIS, there is no specific information demonstrating that injurious “takes” would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate the number of potential exposures to sound levels  $>160$  dB re  $1 \mu\text{Pa}_{\text{rms}}$  and present estimates of the numbers of marine mammals that could be affected during the proposed seismic survey. The estimates are based on consideration of the number of marine mammals that could be disturbed appreciably by  $\sim 3263$  km of seismic surveys in the South Atlantic Ocean. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection.

**Basis for Estimating Exposure.**—The estimates are based on a consideration of the number of marine mammals that could be within the area around the operating airgun array where received levels of sound  $>160$  dB re  $1 \mu\text{Pa}_{\text{rms}}$  are predicted to occur (see Table 1). The estimated numbers are based on the densities (numbers per unit area) of marine mammals expected to occur in the area in the absence of a seismic survey. To the extent that marine mammals tend to move away from seismic sources before the sound level reaches the criterion level and tend not to approach an operating airgun array, these estimates likely overestimate the numbers actually exposed to the specified level of sound. The overestimation is expected to be particularly large when dealing with the higher sound-level criteria, e.g., 180 dB re  $1 \mu\text{Pa}_{\text{rms}}$ , as animals are more likely to move away before received levels reach 180 dB than they are to move away before it reaches (for example) 160 dB re  $1 \mu\text{Pa}_{\text{rms}}$ . Likewise, they are less likely to approach within the  $\geq 180$ - or 190-dB re  $1 \mu\text{Pa}_{\text{rms}}$  radii than they are to approach within the considerably larger  $\geq 160$ -dB radius.

Density estimates are not available for the proposed survey area. Thus, we have applied density estimates available from the regions nearest to the proposed survey area to species expected to be uncommon there. No marine mammal species are expected to be common in the proposed survey area; density estimates are considered to be zero for species expected to be rare. Densities for sei, fin, sperm, Cuvier's beaked, and long-finned pilot whales, and for the southern right whale dolphin are based on density estimates calculated by AECOM (2014) for an NSF marine geophysical survey in the Scotia Sea and South Atlantic Ocean at  $\sim 53$ – $58^\circ\text{S}$ ,  $30$ – $40^\circ\text{W}$ ; densities were from the Navy Marine Species Density Database (NMSDD).

The density estimate for rough-toothed dolphins is based on sightings during shipboard winter surveys along a coastal-offshore gradient in the Vitória-Trindade Chain, western South Atlantic Ocean, during August–September 2010 (Wedekin et al. 2014). The density estimates for pantropical spotted dolphin and short-finned pilot whale are based on sightings on vessel surveys off Gabon between March and August 2009 (de Boer 2010). We calculated densities using standard line-transect methods (Buckland et al. 2001); densities were corrected for trackline lateral detection probability bias [ $f(0)$ ] and availability [ $g_a(0)$ ] and detectability [ $g_d(0)$ ] biases from Forney and Barlow (1998). Density estimates for three uncommon species (short-beaked common and Fraser's dolphins, and pygmy killer whale) are not available as no sightings have been reported during systematic surveys in the South Atlantic Ocean; therefore, densities for these species are assumed to be zero. Species classified as rare in Table 3 that are not listed as **Endangered** under the ESA (see Table 1), or for which there are no confirmed sightings in or reasonably near the survey area in the OBIS database (OBIS 2015), are not included in Table 4.

There is some uncertainty about the representativeness of the estimated density data and the assumptions used in the calculations. Notably, the calculated density estimates originate from different surveys covering various seasons and different regions, some  $>3000$  km away from the proposed survey area. However, the approach used here is based on the best available data, and the calculated exposures that are based on these densities are best estimates for the proposed survey for any time of the year.

The estimated numbers of individuals that may be “taken by harassment” (Level B takes) are based on the 160-dB re  $1 \mu\text{Pa}_{\text{rms}}$  criterion for all cetaceans and pinnipeds. It is assumed that marine mammals exposed to airgun sounds that strong could change their behavior sufficiently. Although injurious or lethal takes are considered extremely unlikely because of marine mammal avoidance of loud sounds and the proposed mitigation and monitoring measures, exposures to received levels  $>180$  dB re  $1 \mu\text{Pa}_{\text{rms}}$  (Level A criterion for cetaceans) were also determined; pinnipeds are considered to be rare in the proposed survey area.

TABLE 4. Densities and estimates of the possible numbers of individuals that could be exposed to  $\geq 160$  and  $\geq 180$  dB re 1  $\mu\text{Pa}_{\text{rms}}$  during the proposed seismic survey in the South Atlantic Ocean during austral summer 2016. The proposed sound source consists of a 36-airgun array with a total discharge volume of  $\sim 6600$  in<sup>3</sup>. Species in italics are listed under the ESA as endangered. The column of numbers in boldface shows the numbers of Level B "takes" for which authorization is requested.

| Species                      | Reported<br>Density<br>(#/1000<br>km <sup>2</sup> ) | Estimated<br>Density<br>(#/1000<br>km <sup>2</sup> ) <sup>1</sup> | Takes using<br>NMFS<br>Methodology <sup>2</sup> |                         | Calculated Take <sup>3</sup> |                         | % of<br>Regional<br>Pop'n <sup>4</sup> | Requested<br>Level B<br>Take<br>Authoriza-<br>tion |
|------------------------------|---|---|---|-------------------------|------------------------------|-------------------------|--|--|
|                              |   |   | Level A<br>(≥180<br>dB)                         | Level B<br>(≥160<br>dB) | Level A<br>(≥180<br>dB)      | Level B<br>(≥160<br>dB) |  |  |
|                              |   |   |   |                         |                              |                         |  |  |
| <b>Mysticetes</b>            |   |   |   |                         |                              |                         |  |  |
| <i>Southern right whale</i>  | 0   | 0   | 0   | 0                       | 0                            | 0                       | 0                                      | <b>2<sup>5</sup></b>                               |
| <i>Humpback whale</i>        | 0   | 0   | 0   | 0                       | 0                            | 0                       | 0                                      | <b>2<sup>5</sup></b>                               |
| <i>Sei whale</i>             | 6.36 <sup>6</sup>                                   | 6.36 <sup>6</sup>   | 65  | 404                     | 44                           | 263                     | 2.6                                    | <b>263</b>   |
| <i>Fin whale</i>             | 18.2 <sup>6</sup>                                   | 18.2 <sup>6</sup>   | 186   | 1157                    | 125                          | 754                     | 5.0                                    | <b>754</b>   |
| <i>Blue whale</i>            | 0   | 0   | 0   | 0                       | 0                            | 0                       | 0                                      | <b>1<sup>5</sup></b>                               |
| <b>Odontocetes</b>           |   |   |   |                         |                              |                         |  |  |
| <i>Sperm whale</i>           | 2.07 <sup>6</sup>                                   | 2.07 <sup>6</sup>   | 21  | 132                     | 14                           | 86                      | 0.8                                    | <b>86</b>  |
| Cuvier's beaked whale        | 0.55 <sup>6</sup>                                   | 0.55 <sup>6</sup>   | 6   | 35                      | 4                            | 23                      | 0                                      | <b>23</b>  |
| Southern bottlenose whale    | 0   | 0   | 0   | 0                       | 0                            | 0                       | 0                                      | <b>2<sup>7</sup></b>                               |
| Rough-toothed dolphin        | 5.95 <sup>8</sup>                                   | 5.95 <sup>8</sup>   | 61  | 379                     | 41                           | 247                     | N/A                                    | <b>247</b>   |
| Pantropical spotted dolphin  | 3.77 <sup>9</sup>                                   | 3.77 <sup>9</sup>   | 38  | 240                     | 26                           | 156                     | N/A                                    | <b>156</b>   |
| Short-beaked common dolphin  | 0   | 0   | 0   | 0                       | 0                            | 0                       | N/A                                    | <b>88<sup>10</sup></b>                             |
| Fraser's dolphin             | 0   | 0   | 0   | 0                       | 0                            | 0                       | N/A                                    | <b>440<sup>10</sup></b>                            |
| Southern right whale dolphin | 6.16 <sup>6</sup>                                   | 6.16 <sup>6</sup>   | 63  | 392                     | 42                           | 255                     | N/A                                    | <b>255</b>   |
| Pygmy killer whale           | 0   | 0   | 0   | 0                       | 0                            | 0                       | N/A                                    | <b>30<sup>10</sup></b>                             |
| Killer whale                 | 0   | 0   | 0   | 0                       | 0                            | 0                       | 0                                      | <b>4<sup>7</sup></b>                               |
| Long-finned pilot whale      | 214.6 <sup>6</sup>                                  | 214.6 <sup>6</sup>  | 2188  | 13642                   | 1471                         | 8884                    | 4.4                                    | <b>8884</b>  |
| Short-finned pilot whale     | 2.09 <sup>9</sup>                                   | 2.09 <sup>9</sup>   | 21  | 133                     | 14                           | 86                      | N/A                                    | <b>86</b>  |
| <b>Pinnipeds</b>             |   |   |   |                         |                              |                         |  |  |
| Southern elephant seal       | 0   | 0   | N/A   | 0                       | N/A                          | 0                       | 0                                      | <b>2<sup>7</sup></b>                               |

N/A = not available or not applicable.

<sup>1</sup> No additional correction factors were applied for these calculations.

<sup>2</sup> NMFS-prescribed methodology for calculated take is estimated density multiplied by the daily ensonified area assuming 200 km of survey/day multiplied by the number of seismic days, including 25% contingency (see NMFS 2015f);  $\geq 160$ -dB ensonified area = 63,580 km<sup>2</sup>;  $\geq 180$ -dB ensonified area = 10,197 km<sup>2</sup>.

<sup>3</sup> Calculated take is estimated density multiplied by the GIS-calculated ensonified area without overlap, including 25% contingency;  $\geq 160$ -dB ensonified area = 41,406 km<sup>2</sup>;  $\geq 180$ -dB ensonified area = 6854 km<sup>2</sup>.

<sup>4</sup> Requested takes (of individuals) expressed as percentages of the populations.

<sup>5</sup> For rare species listed as **endangered** under the ESA, the requested take authorization was increased to mean group size off the Antarctic Peninsula and South Georgia for southern right and humpback whales (Williams et al. 2006), and for the MAR in the North Atlantic for blue whales (Waring et al. 2008).

<sup>6</sup> Densities estimated by AECOM (2014) for the Scotia Sea and South Atlantic Ocean.

<sup>7</sup> For rare species with sightings near the survey area in the OBIS database (OBIS 2015), requested take authorization was increased to mean group size off the Antarctic Peninsula and South Georgia for southern bottlenose and killer whales (Williams et al. 2006), and to mean group size of the three nearest records to the survey area for southern elephant seals (Lewis et al. 2006b).

<sup>8</sup> Densities estimated from Wedekin et al. (2014) for the western South Atlantic Ocean (see text).

<sup>9</sup> Densities estimated from de Boer (2010) off Gabon (see text).

<sup>10</sup> For uncommon species with no density estimate available, requested take authorization increased to mean group size off northern Angola for short-beaked common dolphin (Weir 2007a), and in the eastern tropical Pacific for Fraser's dolphin and pygmy killer whale (Ferguson et al. 2006).

Table 4 shows the density estimates calculated as described above and the estimates of the number of different individual marine mammals that potentially could be exposed to  $\geq 160$  and  $\geq 180$  dB re 1  $\mu\text{Pa}_{\text{rms}}$  during the seismic survey if no animals moved away from the survey vessel. The *Requested Take Authorization* for Level B takes is given in the far right column of Table 4. For uncommon species for which densities were not available, and for rare species listed as *Endangered* under the ESA or for which there are confirmed sightings in or reasonably near the survey area in the OBIS database (OBIS 2015), we have included a *Requested Take Authorization* for the mean group size for the species at the nearest available location (see Table 4 for sources).

It should be noted that the following estimates of exposures assume that the proposed survey would be completed; in fact, the ensonified area calculated using the planned number of line-kilometers *has been increased by 25%* to accommodate turns, lines that may need to be repeated, equipment testing, etc. As is typical during offshore seismic surveys, inclement weather and equipment malfunctions likely would cause delays and might limit the number of useful line-kilometers of seismic operations that can be undertaken. Also, any marine mammal sightings within or near the designated EZ would result in the shut down of seismic operations as a mitigation measure. Thus, the following estimates of the numbers of marine mammals potentially exposed to 160-dB re 1  $\mu\text{Pa}_{\text{rms}}$  sounds are precautionary and probably overestimate the actual numbers of marine mammals that could be involved. These estimates assume that there would be no weather, equipment, or mitigation delays, which is highly unlikely.

Consideration should be given to the hypothesis that delphinids are less responsive to airgun sounds than are mysticetes, as referenced in both the PEIS and § 4.1.1.1 of this document. The 160-dB(rms) criterion currently applied by NMFS, on which the following estimates are based, was developed based primarily on data from gray and bowhead whales. The estimates of “takes by harassment” of delphinids are thus considered precautionary. As noted previously, in July 2015, NOAA made available for a second public comment period new draft guidance for assessing the effects of anthropogenic sound on marine mammals (NOAA 2015a), although at the time of preparation of this Draft EA, the date of release of the final guidelines and how they would be implemented are unknown. Available data suggest that the current use of a 160-dB criterion could be improved upon, as behavioral response might not occur for some percentage of marine mammals exposed to received levels  $>160$  dB, whereas other individuals or groups might respond in a manner considered as “taken” to sound levels  $<160$  dB (NMFS 2013c). It has become evident that the context of an exposure of a marine mammal to sound can affect the animal’s initial response to the sound (NMFS 2013c).

NMFS does not provide specific guidance or requirements for IHA Applicants or for Section 7 ESA consultation for the development of take estimates and multiple exposure analysis, therefore variation in methodologies and calculations are likely to occur. Here we follow a methodology that has been used successfully for past NSF seismic surveys to generate take estimates for the MMPA and ESA processes. That method uses GIS to calculate ensonified areas using the geometry of the survey and the modeled propagation distances. However, as requested by NMFS, we also present in Table 4 the results using their methodology (see footnote 2 in Table 4).

***Potential Number of Marine Mammals Exposed.***—The number of different individuals that could be exposed to airgun sounds with received levels  $\geq 160$  dB re 1  $\mu\text{Pa}_{\text{rms}}$  on one or more occasions can be estimated by considering the total marine area that would be within the 160-dB radius around the operating seismic source on at least one occasion, along with the expected density of animals in the area. The number of possible exposures (including repeated exposures of the same individuals) can be estimated by considering the total marine area that would be within the 160-dB radius around the operating

airguns, including areas of overlap. During the proposed primary survey in the South Atlantic Ocean, the area including overlap is ~1.2 times the area excluding overlap, so a marine mammal that stayed in that survey area during the survey would typically be exposed only once, on average. It is unlikely that a particular animal would stay in the area during the entire survey. The numbers of different individuals potentially exposed to  $\geq 160$  dB re 1  $\mu\text{Pa}_{\text{rms}}$  were calculated by multiplying the expected species density times the anticipated area to be ensonified to that level during airgun operations excluding overlap. The area expected to be ensonified was determined by entering the planned survey lines into a MapInfo GIS, using the GIS to identify the relevant areas by “drawing” the applicable 160-dB buffer (see Table 1) around each seismic line, and then calculating the total area within the buffers.

Applying the approach described above, ~33,125 km<sup>2</sup> (41,406 km<sup>2</sup> including the 25% contingency) would be within the 160-dB isopleth on one or more occasions in the South Atlantic Ocean during the proposed survey. Because this approach does not allow for turnover in the mammal populations in the area during the course of the survey, the actual number of individuals exposed could be underestimated, although the conservative (i.e., probably overestimated) line-kilometer distances used to calculate the area could offset this. Also, the approach assumes that no cetaceans would move away or toward the trackline in response to increasing sound levels before the levels reach 160 dB as the *Langseth* approaches. Another way of interpreting the estimates is that they represent the number of individuals that are expected (in the absence of a seismic program) to occur in the waters that would be exposed to  $\geq 160$  dB re 1  $\mu\text{Pa}_{\text{rms}}$ .

The estimate of the number of individual marine mammals that could be exposed to seismic sounds with received levels  $\geq 160$  dB re 1  $\mu\text{Pa}_{\text{rms}}$  during the proposed survey is 10,754 (Table 4). That total includes 1103 cetaceans listed as *Endangered* under the ESA: 86 sperm whales, 754 fin whales, and 263 sei whales, representing 0.8%, 5.0%, and 2.6% of their regional populations (also see Table 3), respectively. In addition, 23 Cuvier’s beaked whales could be exposed during the survey (Table 4). Most (89.5%) of the cetaceans potentially exposed would be delphinids; the long-finned pilot whale, southern right whale dolphin, rough-toothed dolphin, and pantropical spotted dolphin, are expected to be the most common delphinid species in the area, with estimates of 8884 (4.4% of the regional population), 255, 247, and 156 exposed to  $\geq 160$  dB re 1  $\mu\text{Pa}_{\text{rms}}$ , respectively.

#### 4.1.1.6 Conclusions for Marine Mammals and Sea Turtles

The proposed seismic project would involve towing a 36-airgun array with a total discharge volume of 6600 in<sup>3</sup> that introduces pulsed sounds into the ocean. Routine vessel operations, other than the proposed seismic operations, are conventionally assumed not to affect marine mammals sufficiently to constitute “taking”.

**Marine Mammals.**—In § 3.6.7, § 3.7.7, and § 3.8.7, the PEIS concluded that airgun operations with implementation of the proposed monitoring and mitigation measures could result in a small number of Level B behavioral effects in some mysticete, odontocete, and pinniped species and that Level A effects were highly unlikely.

In this analysis, estimates of the numbers of marine mammals that could be exposed to airgun sounds during the proposed program have been presented, together with the requested “take authorization”. The estimated numbers of animals potentially exposed to sound levels sufficient to cause appreciable disturbance are low percentages of the regional population sizes (Table 4). The estimates are likely overestimates of the actual number of animals that would be exposed to and would react to the seismic sounds. The reasons for that conclusion are outlined above. The relatively short-term exposures

are unlikely to result in any long-term negative consequences for the individuals or their populations. Therefore, no significant impacts on cetaceans or pinnipeds would be expected from the proposed activity.

In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related marine mammal injuries or mortality. Also, actual numbers of animals potentially exposed to sound levels sufficient to cause disturbance (i.e., are considered takes) have almost always been much lower than predicted and authorized takes. For example, during an NSF-funded, ~5000-km, 2-D seismic survey conducted by the *Langseth* off the coast of North Carolina in September–October 2014, only 296 cetaceans were observed within the predicted 160-dB zone and potentially taken, representing <2% of the 15,498 takes authorized by NMFS (RPS 2015). During an USGS-funded, ~2700 km, 2-D seismic survey conducted by the *Langseth* along the U.S. east coast in August–September 2014, only 3 unidentified dolphins were observed within the predicted 160-dB zone and potentially taken, representing <0.03% of the 11,367 authorized takes (RPS 2014b).

**Sea Turtles.**—In § 3.4.7, the PEIS concluded that with implementation of the proposed monitoring and mitigation measures, no significant impacts of airgun operations are likely to sea turtle populations in any of the analysis areas, and that any effects are likely to be limited to short-term behavioral disturbance and short-term localized avoidance of an area of unknown size near the active airguns. In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related sea turtle injuries or mortality. Five species of sea turtles could be encountered in the proposed survey area. Given the proposed activity, no significant impacts on sea turtles would be expected.

#### **4.1.2 Direct Effects on Invertebrates, Fish, Fisheries, and EFH and Their Significance**

Effects of seismic sound on marine invertebrates (crustaceans and cephalopods), marine fish, and their fisheries are discussed in § 3.2.4 and § 3.3.4 and Appendix D of the PEIS. Relevant new studies on the effects of sound on marine invertebrates, fish, and fisheries that have been published since the release of the PEIS are summarized below. Although research on the effects of exposure to airgun sound on marine invertebrates and fishes is increasing, many data gaps remain (Hawkins et al. 2015).

##### **4.1.2.1 Effects of Sound on Marine Invertebrates**

Fewtrell and McCauley (2012) exposed captive squid (*Sepioteuthis australis*) to pulses from a single airgun; the received sound levels ranged from 120 to 184 dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$  SEL. Increases in alarm responses were seen at SELs >147–151 dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$ ; the squid were seen to discharge ink or change their swimming pattern or vertical position in the water column. Solé et al. (2013) exposed four caged cephalopod species to low-frequency (50–400 Hz) sinusoidal wave sweeps (with a 1-s sweep period for 2 h) with received levels of  $157 \pm 5$  dB re 1  $\mu\text{Pa}$ , and peak levels up to 175 dB re 1  $\mu\text{Pa}$ . Besides exhibiting startle responses, all four species examined received damage to the statocyst, which is the organ responsible for equilibrium and movement. The animals showed stressed behavior, decreased activity, and loss of muscle tone.

When New Zealand scallop (*Pecten novaezelandiae*) larvae were exposed to recorded seismic pulses, significant developmental delays were reported, and 46% of the larvae exhibited body abnormalities; it was suggested that the malformations could be attributable to cumulative exposure (de Soto et al. 2013). Their experiment used larvae enclosed in 60-ml flasks suspended in a 2-m diameter by

1.3-m water depth tank and exposed to a playback of seismic sound at a distance of 5–10 cm. Other studies conducted in the field have shown no effects on Dungeness crab larvae or snow crab embryos (Pearson et al. 1994, DFOC 2004 in NSF PEIS).

Celi et al. (2013) exposed captive red swamp crayfish (*Procambarus clarkia*) to linear sweeps with a frequency range of 0.1–25 kHz and a peak amplitude of 148 dB re 1  $\mu\text{Pa}$  rms at 12 kHz for 30 min. They found that the noise exposure caused changes in the haemato-immunological parameters (indicating stress) and reduced agonistic behaviors.

#### 4.1.2.2 Effects of Sound on Fish

Potential impacts of exposure to airgun sound on marine fishes have been reviewed by Popper (2009), Popper and Hastings (2009a,b), and Fay and Popper (2012); they include pathological, physiological, and behavioral effects. Radford et al. (2014) suggested that masking of key environmental sounds or social signals could also be a potential negative effect from sound. Popper et al. (2014) presented guidelines for seismic sound level thresholds related to potential effects on fish. The effect types discussed include mortality, mortal injury, recoverable injury, temporary threshold shift, masking, and behavioral effects. Seismic sound level thresholds were discussed in relation to fish without swim bladders, fish with swim bladders, and fish eggs and larvae.

Bui et al. (2013) examined the behavioral responses of Atlantic salmon (*Salmo salar* L.) to light, sound, and surface disturbance events. They reported that the fish showed short-term avoidance responses to the three stimuli. Salmon that were exposed to 12 Hz sounds and/or surface disturbances increased their swimming speeds.

Peña et al. (2013) used an omnidirectional fisheries sonar to determine the effects of a 3-D seismic survey off Vesterålen, northern Norway, on feeding herring (*Clupea harengus*). They reported that herring schools did not react to the seismic survey; no significant changes were detected in swimming speed, swim direction, or school size when the drifting seismic vessel approached the fish from a distance of 27 km to 2 km over a 6-h period. Peña et al. (2013) attributed the lack of response to strong motivation for feeding, the slow approach of the seismic vessel, and an increased tolerance to airgun sounds.

Miller and Cripps (2013) used underwater visual census to examine the effect of a seismic survey on a shallow-water coral reef fish community in Australia. The census took place at six sites on the reef before and after the survey. When the census data collected during the seismic program were combined with historical data, the analyses showed that the seismic survey had no significant effect on the overall abundance or species richness of reef fish. This was in part attributed to the design of the seismic survey (e.g.,  $\geq 400$  m buffer zone around reef), which reduced the impacts of seismic sounds on the fish communities by exposing them to relatively low SELs ( $< 187$  dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$ ). Fewtrell and McCauley (2012) exposed pink snapper (*Pagrus auratus*) and trevally (*Pseudocaranx dentex*) to pulses from a single airgun; the received sound levels ranged from 120 to 184 dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$  SEL. Increases in alarm responses were seen in the fish at SELs  $> 147$ – $151$  dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$ ; the fish swam faster and formed more cohesive groups in response to the airgun sounds.

Hastings and Miksis-Olds (2012) measured the hearing sensitivity of caged reef fish following exposure to a seismic survey in Australia. When the auditory evoked potentials (AEP) were examined for fish that had been in cages as close as 45 m from the pass of the seismic vessel and at water depth of 5 m, there was no evidence of TTS in any of the fish examined, even though the cumulative SELs had reached 190 dB re 1  $\mu\text{Pa}^2 \cdot \text{s}$ .

Popper et al. (2013) conducted a study that examined the effects of exposure to seismic airgun sound on caged pallid sturgeon (*Scaphirhynchus albus*) and paddlefish (*Polyodon spathula*); the maximum received peak SPL in this study was 224 dB re 1  $\mu$ Pa. Results of the study indicated no mortality, either during or seven days after exposure, and no statistical differences in effects on body tissues between exposed and control fish.

Andrews et al. (2014) conducted functional genomic studies on the inner ear of Atlantic salmon (*Salmo salar*) that had been exposed to seismic airgun sound. The airguns had a maximum SPL of ~145 dB re 1  $\mu$ Pa<sup>2</sup>/Hz and the fish were exposed to 50 discharges per trial. The results provided evidence that fish exposed to seismic sound either increased or decreased their expressions of different genes, demonstrating that seismic sound can affect fish on a genetic level.

#### 4.1.2.3 Effects of Sound on Fisheries

Handegard et al. (2013) examined different exposure metrics to explain the disturbance of seismic surveys on fish. They applied metrics to two experiments in Norwegian waters, during which fish distribution and fisheries were affected by airguns. Even though the disturbance for one experiment was greater, the other appeared to have the stronger SEL, based on a relatively complex propagation model. Handegard et al. (2013) recommended that simple sound propagation models should be avoided and that the use of sound energy metrics like SEL to interpret disturbance effects should be done with caution. In this case, the simplest model (exposures per area) best explained the disturbance effect.

Hovem et al. (2012) used a model to predict the effects of airgun sounds on fish populations. Modeled SELs were compared with empirical data and were then compared with startle response levels for cod. This work suggested that in the future, particular acoustic-biological models could be useful in designing and planning seismic surveys to minimize disturbance to fishing. Their preliminary analyses indicated that seismic surveys should occur at a distance of 5–10 km from fishing areas, in order to minimize potential effects on fishing.

In their introduction, Løkkeborg et al. (2012) described three studies in the 1990s that showed effects on fisheries. Results of a study off Norway in 2009 indicated that fishes reacted to airgun sound based on observed changes in catch rates during seismic shooting; gillnet catches increased during the seismic shooting, likely a result of increased fish activity, whereas longline catches decreased overall (Løkkeborg et al. 2012).

#### 4.1.2.4 Conclusions for Invertebrates, Fish and Fisheries

This newly available information does not affect the outcome of the effects assessment as presented in the PEIS. The PEIS concluded that there could be changes in behavior and other non-lethal, short-term, temporary impacts, and injurious or mortal impacts on a small number of individuals within a few meters of a high-energy acoustic source, but that there would be no significant impacts of NSF-funded marine seismic research on populations. The PEIS also concluded that seismic surveys could cause temporary, localized reduced fish catch to some species, but that effects on commercial and recreation fisheries were not significant.

Interactions between the proposed survey and commercial fishing in the survey area are expected to be limited. Two possible conflicts in general are the *Langseth*'s streamer entangling with fishing gear and displacement of fishers from the survey area. Fishing activities could occur within the survey area; however, a safe distance would need to be kept from the *Langseth* and the towed seismic equipment. Conflicts would be avoided through communication with the fishing community during the survey.

Seven OBS instruments would be deployed at each of five locations during the survey. All OBSs would be recovered after the proposed survey. The OBS anchors either are 23-kg pieces of hot-rolled steel that have a footprint of 0.3×0.4 m or 36-kg iron grates with a footprint of 0.9×0.9 m. OBS anchors would be left behind upon equipment recovery. Although OBS placement would disrupt a very small area of seafloor habitat and could disturb benthic invertebrates, the impacts are expected to be localized and transitory.

Given the proposed activity, no significant impacts on marine invertebrates, marine fish, and their fisheries would be expected. In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, PSOs and other crew members have not observed any seismic sound-related fish or invertebrate injuries or mortality.

#### **4.1.3 Direct Effects on Seabirds and Their Significance**

Effects of seismic sound and other aspects of seismic operations (collisions, entanglement, and ingestion) on seabirds are discussed in § 3.5.4 of the PEIS. The PEIS concluded that there could be transitory disturbance, but that there would be no significant impacts of NSF-funded marine seismic research on seabirds or their populations. Given the proposed activity, no significant impacts on seabirds would be expected. In decades of seismic surveys carried out by the *Langseth* and its predecessor, the R/V *Ewing*, PSOs and other crew members have seen no seismic sound-related seabird injuries or mortality.

#### **4.1.4 Indirect Effects on Marine Mammals, Sea Turtles, Seabirds and Fish and Their Significance**

The proposed seismic operations would not result in any permanent impact on habitats used by marine mammals, sea turtles, or seabirds or to the food sources they use. The main impact issue associated with the proposed activity would be temporarily elevated noise levels and the associated direct effects on these species, as discussed above.

During the proposed seismic survey, only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species and invertebrates would be short-term, and fish would return to their pre-disturbance behavior once the seismic activity ceased. Thus, the proposed survey would have little impact on the abilities of marine mammals or sea turtles to feed in the area where seismic work is planned. No significant indirect impacts on marine mammals, sea turtles, or fish would be expected.

#### **4.1.5 Cumulative Effects**

According to Nowacek et al. (2015), cumulative impacts have a high potential of disturbing marine mammals. Wright and Kyhn (2014) recently proposed practical management steps to limit cumulative impacts, including minimizing exposure by reducing exposure rates and levels. The results of the cumulative impacts analysis in the PEIS indicated that there would not be any significant cumulative effects to marine resources from the proposed NSF-funded marine seismic research, including the combined use of airguns, MBES, SBP, and acoustic pingers. However, the PEIS also stated that, “A more detailed, cruise-specific cumulative effects analysis would be conducted at the time of the preparation of the cruise-specific EAs, allowing for the identification of other potential activities in the area of the proposed seismic survey that may result in cumulative impacts to environmental resources.”

Here we focus on activities that could impact animals specifically in the proposed survey area (e.g., research activities, vessel traffic, and commercial fisheries).

Although there is a military base on Ascension Island that is maintained by the U.K. Royal Air Force (RAF 2015), no information regarding potential upcoming military activity in the proposed survey area could be located at the time of writing. Oil and gas activities are currently underway north and south of the Rio Grande Rise (offshore Brazil in the Santos and Campos basins in the Brazilian margin) and the Walvis Ridge (offshore Namibia in the Namibian margin), with exploration and/or drilling activities occurring over the past several decades in some locations (Knight and Westwood 1999; Mello et al. 2012). However, there are no known oil and gas activities that have been conducted or will occur in the proposed survey area.

#### 4.1.5.1 Past and future research activities in the area

In the late 1960s, analog single-channel seismic data were acquired for the Deep Sea Drilling Project (DSDP) Expedition 3 near the proposed survey area. Two sites were drilled there during the expedition, along with numerous other sites throughout the South Atlantic Ocean (IODP 2014). Results from that geophysical program were used as a site survey for the IODP 853 pre-proposal, *A Multidisciplinary IODP Investigation along a Crustal Flow-line Across the Western Flank of the Southern Mid-Atlantic Ridge: The South Atlantic Transect* (Coggon et al. 2014). The proposed seismic survey would provide essential site survey information for the IODP expedition, which could occur in 2016 when the IODP vessel arrives in the South Atlantic. The IODP expedition would investigate five sites using drilling and coring along ~30°S (Coggon et al. 2014) and would address hydrothermal contributions to global geochemical cycles and the response of ocean circulation to changing climate. In 1979, the University of Texas conducted a marine seismic reflection survey (FM0105) near the Rio Grande Rise in the South Atlantic Ocean using the R/V *Fred H. Moore* and a 3-airgun array totaling 4500 in<sup>3</sup> (NOAA 2015b).

Several research surveys have also been conducted on the Walvis Ridge. During June–July 1980, The *Glomar Challenger* collected cores from five drill sites (~28–30°S, ~1°–30°E) as a component of the DSDP (Moore et al. 1984). In winter 2000, the *Meteor* (Cruise M49/1) completed a seismic survey of the southeastern Walvis Ridge (Spieß et al. 2003). The high-fidelity MCS data generated during the survey were used to develop the drilling strategy for Ocean Drilling Program (ODP) Leg 208 that was conducted on the Walvis Ridge during 6 March–6 May 2003 (Shipboard Scientific Party 2003). In addition, seamount fisheries surveys have been completed on Walvis Ridge seamounts (Clark et al. 2007), an area managed by SEAFO (Rogers and Gianni 2010). During November 2009, the R/V *Akademik Ioffe* completed benthic and pelagic sampling of biota along the southern MAR (~0–20°S) and the Walvis Ridge (20–33°S, 5°W–10°E), which initiated the South Atlantic expansion of the MAR-ECO project (Patterns and Processes of the Ecosystems of the Northern Mid-Atlantic) with a focus on improving knowledge of biodiversity in the region (Perez et al. 2012; Shirshov Institute n.d.).

Other scientific seismic research activities could be conducted in this region in the future; however, aside from those noted here, no other marine geophysical surveys using the *Langseth* are currently proposed in the region in the foreseeable future. At the present time, the proponents of the survey are not aware of other marine research activities planned to occur in the proposed survey areas during the austral summer 2016 timeframe, but research activities planned by other entities are possible.

#### 4.1.5.2 Vessel traffic

Vessel traffic in and around the proposed survey area likely would exclusively consist of commercial vessels. Based on data made available through the Automated Mutual-Assistance Vessel Rescue (AMVER) system managed by the U.S. Coast Guard (USCG), up to 14 commercial vessels per month typically passed near the proposed survey area during 2007–2013 (USCG 2013). These data further indicated there is a shipping route to the immediate north and northeast of the proposed survey area, between the southeastern portion of Brazil (near Cabo Frio and Rio de Janeiro) and the southern tip of South Africa.

Live vessel traffic information is available from MarineTraffic (2015) and FleetMon (2015), including vessel names, types, flags, positions, and destinations. There were no vessels in the general vicinity of the proposed survey area when those sources were accessed on 21 April and 7 May 2015. The nearest vessels to the proposed survey area were along the Brazilian coast (FleetMon 2015; MarineTraffic 2015).

The total transit distance of ~10,700 km (including transit to and from port, and OBS deployment/recovery) by L-DEO's vessel *Langseth* would be small relative to total transit length for vessels operating in the general region around the proposed survey area during austral summer. Thus, the addition of L-DEO's vessel traffic to existing shipping and fishing operations (see below) is expected to result in a only a minor increase in overall ship traffic.

#### 4.1.5.3 Fisheries

The commercial fisheries in the general area of the proposed survey are described in § III. The primary contributions of fishing to potential cumulative impacts on marine mammals and sea turtles involve noise, potential entanglement, and removal of prey items (e.g., Reeves et al. 2003). There might be some localized avoidance by marine mammals of fishing vessels near the proposed seismic survey area.

Leatherback, hawksbill, loggerhead, and green turtles are taken as bycatch in the pelagic longline fishery off the coast of South Africa (Petersen et al. 2008a), and leatherback and olive ridley turtles are taken in the Gulf of Guinea and St. Helena (Carranza et al. 2006). Leatherback, loggerhead, olive ridley, and green turtles are taken as bycatch in the pelagic longline and driftnet fisheries off the coasts of Brazil and Uruguay (Katos et al. 2004; Lewison et al. 2004; Pinedo and Polacheck 2004; Marcovaldi et al. 2006; Sales et al. 2010). Leatherback, loggerhead, and green turtles are taken as bycatch in the gillnet fishery off Argentina (González Carman et al. 2011), and green turtles are taken as bycatch in the gillnet fishery off southern Brazil (López-Barrera et al. 2012). Leatherback, loggerhead, olive ridley, and green turtles are taken in the hook-and-line fishery along the Brazilian shelf (Bugoni et al. 2008), and leatherback and green turtles have also been reported as bycatch in the longline fishery around Trindade and Martim Vaz islands (Pinheiro et al. 2010).

Dead stranded leatherback, loggerhead, olive ridley, and green turtles have also been reported along the coast of Brazil (Bugoni et al. 2001; Mascarenhas et al. 2004) and Uruguay (Vélez-Rubio et al. 2013). During 1997–1998, 5 of 38 stranded green turtles died from ingesting anthropogenic debris, and 3 of 22 loggerheads and 1 of 56 green turtles died because of fishing activities in Brazil (Bugoni et al. 2001). A total of 1107 turtles stranded in Uruguay during 1999–2010, mostly consisting of green (643), loggerhead (329), and leatherback (131) turtles, although 3 hawksbills and 1 olive ridley turtle were also documented; the main causes of strandings (and death) were attributed to fishery interactions and ingestion of debris (Vélez-Rubio et al. 2013). In addition, the Argentine angelshark is taken as bycatch in

the gillnet monkfish fishery off south Brazil (Perez et al. 2005), and the scalloped hammerhead, common thresher, and porbeagle sharks are taken in longline fishing operations off South Africa (Petersen et al. 2008b).

Although Uruguyan longline fishing does occur in the proposed survey area, no marine mammal bycatch was reported for the region during 1996–2007 (Passadore et al. 2015b). However, delphinids (including killer whales and *Delphinus* sp.) and pinnipeds (*Arctocephalus* sp.) were taken as bycatch in the longline fishery off Uruguay (Passadore et al. 2015b). Marine mammals are also bycaught in gillnets and driftnets off Brazil, Uruguay, Argentina, and South Africa (Di Benedetto et al. 1998; Zerbini and Kotas 1998; Di Benedetto 2003; Reeves et al. 2013). Species that have been caught incidentally in these fisheries include southern right, humpback, Bryde’s, sperm, dwarf sperm, false killer, and long-finned pilot whales, and long-beaked common, short-beaked common, bottlenose, rough-toothed, Clymene, striped, Atlantic spotted, and spinner dolphins (Di Benedetto et al. 1998; Zerbini and Kotas 1998; Reeves et al. 2013).

There might be some localized avoidance by marine mammals of fishing vessels near the proposed seismic survey area. L-DEO’s operations in the proposed survey area are limited (duration of ~32 days), and the addition of L-DEO’s operations to existing commercial fishing operations is expected to result in only a negligible increase in overall disturbance effects on marine mammals and sea turtles. The addition of L-DEO’s operations to existing fishing operations would result in no increase in serious injuries or mortality in marine mammals.

#### **4.1.6 Unavoidable Impacts**

Unavoidable impacts to the species of marine mammals and turtles occurring in the proposed survey area would be limited to short-term, localized changes in behavior of individuals. For cetaceans, some of the changes in behavior may be considered to fall within the MMPA definition of “Level B Harassment” (behavioral disturbance; no serious injury or mortality). TTS, if it occurs, would be limited to a few individuals, is a temporary phenomenon that does not involve injury, and is unlikely to have long term consequences for the few individuals involved. No long-term or significant impacts would be expected on any of these individual marine mammals or turtles, or on the populations to which they belong. Effects on recruitment or survival would be expected to be (at most) negligible.

#### **4.1.7 Coordination with Other Agencies and Processes**

This Draft EA has been prepared by LGL on behalf of L-DEO and NSF pursuant to Executive Order 12114. Potential impacts to endangered species and critical habitat have also been assessed in the document; therefore, it will be used to support the ESA Section 7 consultation process with NMFS and USFWS. This document will also be used as supporting documentation for an IHA application submitted by L-DEO to NMFS, under the U.S. MMPA, for “taking by harassment” (disturbance) of small numbers of marine mammals, for this proposed seismic survey.

L-DEO and NSF have coordinated, and will continue to coordinate, with other applicable Federal agencies as required, and will comply with their requirements.

### **4.2 Alternative Action: Another Time**

An alternative to issuing the IHA for the period requested, and to conducting the Project then, is to issue the IHA for another season, and to conduct the project at that alternative season. The proposed

timing for the cruise (austral summer 2016) is the season when the personnel and equipment essential to meet the overall project objectives are available.

Marine mammals and sea turtles are expected to be found throughout the proposed survey area and throughout the time during which the project would occur. Most marine mammal species are expected to occur in the area year-round, although some baleen whales may occur farther south at the time of the survey. Thus, altering the timing of the proposed project likely would result in no net benefits for marine mammals. A change in the survey timing to a different season would not result in a change to the take estimates presented in Table 4 because the best available species densities for any time of the year have been used.

### **4.3 No Action Alternative**

An alternative to conducting the proposed activity is the “No Action” Alternative, i.e., do not issue an IHA and do not conduct the operations. If the research were not conducted, the “No Action” alternative would result in no disturbance to marine mammals or sea turtles attributable to the proposed activity; however, valuable data about the marine environment would be lost. Research that would contribute to understanding the evolution of the South Atlantic oceanic crust would be lost and greater understanding of Earth processes would not be gained. The No Action Alternative would not meet the purpose and need for the proposed activity.

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## VI LITERATURE CITED

- AECOM. 2014. Request by the National Science Foundation for an Incidental Harassment Authorization to allow the incidental take of marine mammals during a marine geophysical survey by the R/VIB *Nathaniel B. Palmer* in the Scotia Sea and South Atlantic Ocean. Rep. from AECOM, Alexandria, VA. Submitted 10 June 2014 to the National Marine Fisheries Service Office of Protected Resources, Silver Spring, MD by the National Science Foundation Division of Polar Programs (PLR), Arlington, VA, the Antarctic Support Contract, Centennial, CO, the University of Texas at Austin Institute for Geophysics, Austin, TX, and the University of Memphis, Memphis, TN. 50 p.
- Aguilar, A. 2009. Fin whale *Balaenoptera physalus*. p. 433-437 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), *Encyclopedia of marine mammals*, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Aguilar Soto, N., M. Johnson, P.T. Madsen, P.L. Tyack, A. Bocconcelli, and J.F. Borsani. 2006. Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? **Mar. Mamm. Sci.** 22(3):690-699.
- Almeida, A.P., C. Baptistotte, and J.A. Schneider. 2000. Loggerhead turtle tagged in Brazil found in Uruguay. **Mar. Turtle Newsl.** 87:10.
- Almeida, A.P., S.A. Eckert, S.C. Bruno, J.T. Scalfoni, B. Giffoni, M. López-Mendilaharsu, and J.C.A. Thomé. 2011a. Satellite-tracked movements of female *Dermochelys coriacea* from southeastern Brazil. **Endang. Spec. Res.** 15(1):77-86.
- Almeida, A.P., L.M.P. Moreira, S.C. Bruno, J.C.A. Thomé, A.S. Martins, A.B. Bolten, and K.A. Bjørndal. 2011b. Green turtle nesting on Trindade Island, Brazil: abundance, trends, and biometrics. **Endang. Spec. Res.** 14(3):193-201.
- Amaral, A.C.Z. and S. Jablonski. 2005. Conservation of marine and coastal biodiversity in Brazil. **Conserv. Biol.** 19(3):625-631.
- Andrews, C.D., J.F. Payne, and M.L. Rise. 2014. Identification of a gene set to evaluate the potential effects of loud sounds from seismic surveys on the ears of fishes: a study with *Salmo salar*. **J. Fish Biol.** 84(6):1793-1819.
- Andriolo, A., C.C.A. Martins, M.H. Engel, J.L. Pizzorno, S. Más-Rosa, A.C. Freitas, M.E. Morete, and P.G. Kinas. 2006. The first aerial survey to estimate abundance of humpback whales (*Megaptera novaeangliae*) in the breeding ground off Brazil (Breeding Stock A). **J. Cetac. Res. Manage.** 8(3):307-311.
- Andriolo, A., P.G. Kinas, M.H. Engel, C.C. Albuquerque Martins, and A.M. Rufino. 2010. Humpback whales within the Brazilian breeding group: distribution and population size estimate. **Endang. Spec. Res.** 11(3):233-243.
- Ansorge, I.J. and J.R.E. Lutjeharms. 2007. The cetacean environment off southern Africa. p. 5-13 In: P.B. Best. 2007. *Whales and dolphins of the southern African subregion*. Cambridge University Press, Cape Town, South Africa. 338 p.
- Arnould, J.P.Y. 2009. Southern fur seals *Arctocephalus* spp. p. 1079-1087 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), *Encyclopedia of marine mammals*, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Atkinson, S., D. Crocker, D. Houser, and K. Mashburn. 2015. Stress physiology in marine mammals: how well do they fit the terrestrial model? **J. Comp. Physiol. B** 185(5):463-486. doi:10.1007/s00360-015-0901-0.
- Baird, R.W. 2009. False killer whale *Pseudorca crassidens*. p. 405-406 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), *Encyclopedia of marine mammals*, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Baird, R.W., S.W. Martin, D.L. Webster, and B.L. Southall. 2014. Assessment of modeled received sound pressure levels and movements of satellite-tagged odontocetes exposed to mid-frequency active sonar at the Pacific

- Missile Range Facility: February 2011 through February 2013. Prepared for U.S. Pacific Fleet, submitted to NAVFAC PAC by HDR Environmental, Operations and Construction, Inc. Accessed on 13 March 2015 at [www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA602847](http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA602847).
- Baker, A.N. 1985. Pgymy right whale *Caperea marginata* (Gray 1846). p. 345-354 In: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 3: The Sirenians and baleen whales. Academic Press, London, U.K. 362 p.
- Baker, A.N. 2001. Status, relationships, and distribution of *Mesoplodon bowdoini* Andrews, 1908 (Cetacea: Ziphiidae). **Mar. Mamm. Sci.** 17(3):473-493.
- Baker, C.S. and L.M. Herman. 1989. Behavioral responses of summering humpback whales to vessel traffic: experimental and opportunistic observations. NPS-NR-TRS-89-01. Rep. from Kewalo Basin Mar. Mamm. Lab., Univ. Hawaii, Honolulu, HI, for U.S. Natl. Park Serv., Anchorage, AK. 50 p. NTIS PB90-198409.
- Baker, C.S., L.M. Herman, B.G. Bays, and W.F. Stifel. 1982. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska. Rep. from Kewalo Basin Mar. Mamm. Lab., Honolulu, HI, for U.S. Nat. Mar. Fish. Serv., Seattle, WA. 78 p.
- Baker, C.S., L.M. Herman, B.G. Bays, and G.B. Bauer. 1983. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1982 season. Rep. from Kewalo Basin Mar. Mamm. Lab., Honolulu, HI, for U.S. Nat. Mar. Mamm. Lab., Seattle, WA. 30 p.
- Baker, C.S., L. Flórez-González, B. Abernethy, H.C. Rosenbaum, R.W. Slade, J. Capella, and J.L. Bannister. 1998. Mitochondrial DNA variation and maternal gene flow among humpback whales of the Southern Hemisphere. **Mar. Mamm. Sci.** 14(4):721-737.
- Barendse, J. and P.B. Best. 2014. Shore-based observations of seasonality, movements, and group behaviour of southern right whales in a nonnursery area on the South African west coast. **Mar. Mamm. Sci.** 30(4):1358-1382.
- Barendse J., P. Best, M. Thornton, C. Pomilla, I. Carvalho, and H.C. Rosenbaum. 2010. Migration redefined? Seasonality, movements, and group composition of humpback whales *Megaptera novaeangliae* off the west coast of South Africa. **African J. Mar. Sci.** 32(1):1-22.
- Barros, N.B., D.A. Duffield, P.H. Ostrom, D.K. Odell, and V.R. Cornish. 1998. Nearshore vs. offshore ecotype differentiation of *Kogia breviceps* and *K. simus* based on hemoglobin, morphometric and dietary analyses. Abstr. World Mar. Mamm. Sci. Conf., 20–24 January, Monaco.
- Barry, S.B., A.C. Cucknell, and N. Clark. 2012. A direct comparison of bottlenose dolphin and common dolphin behaviour during seismic surveys when airguns are and are not being utilised. p. 273-276 In: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.
- Bellini, C., T.M. Sanches, and A. Formia. 2000. Hawksbill turtle tagged in Brazil captured in Gabon, Africa. **Mar. Turtle Newsl.** 87:11-12.
- Bensch, A., M. Gianni, D. Gréboval, J.S. Saunders, and A. Hjort. 2009. Worldwide review of bottom fisheries in the high seas. FAO Fisheries and Aquaculture Tech. Pap. No. 522, Rev. 1. Rome, Italy. 145 p. Available at <http://www.fao.org/docrep/012/i11116e/i11116e00.htm>.
- Bernstein, L. 2013. The Washington Post: Health, Science, and Environment. Panel links underwater mapping sonar to whale stranding for first time. Published 6 October 2013. Accessed on 11 June 2015 at [http://www.washingtonpost.com/national/health-science/panel-links-underwater-mapping-sonar-to-whale-stranding-for-first-time/2013/10/06/52510204-2e8e-11e3-bbed-a8a60c601153\\_story.html](http://www.washingtonpost.com/national/health-science/panel-links-underwater-mapping-sonar-to-whale-stranding-for-first-time/2013/10/06/52510204-2e8e-11e3-bbed-a8a60c601153_story.html).
- Best, P.B. 2001. Distribution and population separation of Bryde's whale *Balaenoptera edeni* off southern Africa. **Mar. Ecol. Prog. Ser.** 220:277-289.

- Best, P.B. 2007. Whales and dolphins of the southern African subregion. Cambridge University Press, Cape Town, South Africa. 338 p.
- Best, P.B. and C.H. Lockyer. 2002. Reproduction, growth and migrations of sei whales *Balaenoptera borealis* off the west coast of South Africa. **S. Afr. J. Mar. Sci.** 24(1):111-133.
- Best, P.B. and M.J. Roscoe. 1974. Survey of right whales off South Africa 1972, with observations from Tristan da Cunha, 1971/1972. **Rep. Int. Whal. Comm.** 24:136-141.
- Best, P.B., R. Payne, V. Rowntree, J. Truda Palazoo, and M.D.C. Both. 1993. Long-range movements of South Atlantic right whales *Eubalaena australis*. **Mar. Mamm. Sci.** 9(3):227-234.
- Best, P.B., J.P. Glass, P.G. Ryan, and M.L. Dalebout. 2009. Cetacean records from Tristan da Cunha, South Atlantic. **J. Mar. Biol. Ass. U.K.** 89(5):1023-1032.
- Best, P.B., M.J. Smale, J. Glass, K. Herian, and S. Von der Heyden. 2014. Identification of stomach contents from a Shepherd's beaked whale *Tasmacetus shepherdi* stranded on Tristan da Cunha, South Atlantic. **J. Mar. Biol. Assoc. U.K.** 94(6):1093-1097.
- Bester M.N. and P.G. Ryan. 2007. Mammals. p. 98–109 *In*: P.G. Ryan (ed.) Field guide to the animals and plants of Tristan da Cunha and Gough Island. Newbury: Pisces Publications for the Tristan Island Government.
- Bester, M.N., H. Möller, J. Wium, and B. Enslin. 2001. An update on the status of southern elephant seals at Gough Island. **S. Afr. J. Wildl. Res.** 41(1&2):68-71.
- Bester, M.N., J.W. Wilson, M.-H. Burle, and G.J.G. Hofmeyr. 2006. Population trends of Subantarctic fur seals at Gough Island. **S. Afr. J. Wildl. Res.** 36(2):191-194.
- Bettridge, S., C.S. Baker, J. Barlow, P.J. Clapham, M. Ford, D. Gouveia, D.K. Mattila, R.M. Pace III, P.E. Rosel, G.K. Silber, and P.R. Wade. 2015. Status review of the humpback whale (*Megaptera novaeangliae*) under the Endangered Species Act. NOAA Tech. Memo. NMFS-SWFSC-540. Nat. Mar. Fish. Service, Southwest Fish. Sci. Center, La Jolla, CA. 240 p.
- Billes, A., J. Fretey, B. Verhage, B. Huijbregts, B. Giffoni, L. Prosdociimi, D.A. Albareda, J.-Y. Georges, and M. Tiwari. 2006. First evidence of leatherback movement from Africa to South America. **Mar. Turtle Newsl.** 111:13-14.
- BirdLife International. 2015. Species factsheet: *Pterodroma madeira*. Accessed on 28 April 2015 at <http://www.birdlife.org>.
- Blackwell, S.B., C.S. Nations, T.L. McDonald, C.R. Greene, Jr., A.M. Thode, M. Guerra, and A.M. Macrander. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. **Mar. Mamm. Sci.** 29(4):E342-E365.
- Blackwell, S.B., C.S. Nations, T.L. McDonald, A.M. Thode, D. Mathias, K.H. Kim, C.R. Greene, Jr., and A.M. Macrander. 2015. Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds. **PLoS ONE** 10(6):e0125720. doi:10.1371/journal.pone.0125720.
- Bolten, A.B., H.R. Martins, M.L. Natali, J.C. Thomé, and M.Â. Marcovaldi. 1990. Loggerhead released in Brazil recaptured in Azores. **Mar. Turtle Newsl.** 48:24-25.
- Boyd, I.L. 2002. Antarctic marine mammals. p. 30-36 *In*: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.) Encyclopedia of Marine Mammals. Academic Press, San Diego, CA. 1414 p.
- Branch, T.A., K.M. Stafford, D.M. Palacios, C. Allison, J.L. Bannister, C.L.K. Burton, E. Cabrera, C.A. Carlson, B. Galletti Vernazzani, P.C. Gill, R. Hucke-Gaete, K.C.S. Jenner, M.-N.M. Jenner, K. Matsuoka, Y.A. Mikhalev, T. Miyashita, M.G. Morrice, S. Nishiwaki, V.J. Sturrock, D. Tormosov, R.C. Anderson, A.N. Baker, P.B. Best, P. Borsa, R.L. Brownell Jr, S. Childerhouse, K.P. Findlay, T. Gerrodette, A.D. Ilankakoon, M. Joergensen, B. Kahn, D.K. Ljungblad, B. Maughan, R.D. McCauley, S. McKay, T.F. Norris, Oman Whale

- and Dolphin Research Group, S. Rankin, F. Samaran, D. Thiele, K. Van Waerebeek and R.M. Warneke. 2007. Past and present distribution, densities, and movements of blue whales *Balaenoptera musculus* in the Southern Hemisphere and northern Indian Ocean. **Mamm. Rev.** 37(2):116-175.
- Branstetter, B.K., J.S. Trickey, H. Aihara, J.J. Finneran, and T.R. Liberman. 2013. Time and frequency metrics related to auditory masking of a 10 kHz tone in bottlenose dolphins (*Tursiops truncatus*). **J. Acoust. Soc. Am.** 134(6):4556-4565.
- Breitzke, M. and T. Bohlen. 2010. Modelling sound propagation in the Southern Ocean to estimate the acoustic impact of seismic research surveys on marine mammals. **Geophys. J. Int.** 181(2):818-846.
- Broker, K., J. Durinck, C. Vanman, and B. Martin. 2013. Monitoring of marine mammals and the sound scape during a seismic survey in two license blocks in the Baffin Bay, West Greenland, in 2012. p. 32 *In: Abstr. 20<sup>th</sup> Bienn. Conf. Biol. Mar. Mamm.*, 9-13 December 2013, Dunedin, New Zealand. 233 p.
- Buckland, S.T., D.R. Anderson, K.P. Burnham, J.L. Laake, D.L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, U.K. 448 p.
- Budylenko, G.A. 1981. Distribution and some aspects of the biology of killer whales in the South Atlantic. **Rep. Intern. Whal. Comm.** 31:523-525.
- Bugoni, L., L. Krause, and M.V. Petry. 2001. Marine debris and human impacts on sea turtles in southern Brazil. **Mar. Poll. Bull.** 42(12):1330-1334.
- Bugoni, L., T.S. Neves, N.O. Leite Jr., D. Carvalho, G. Sales, R.W. Furness, C.E. Stein, F.V. Peppes, B.B. Giffoni, and D.S. Monteiro. 2008. Potential bycatch of seabirds and turtles in hook-and-line fisheries of the Itaipava Fleet, Brazil. **Fish. Res.** 90:217-224.
- Bui, S., F. Oppedal, Ø.J. Korsøen, D. Sonny, and T. Dempster. 2013. Group behavioural responses of Atlantic salmon (*Salmo salar* L.) to light, infrasound and sound stimuli. **PLoS ONE** 8(5):e63696. doi:10.1371/journal.pone.0063696.
- Campagna, C., M.N. Lewis, and M.R. Marin. 2006. Locations of Seals in Patagonian Large Marine Ecosystem. In: Ashore and at sea distribution of seals. Centro Nacional Patagónico, Puerto Madryn, Argentina. Retrieved from <http://www.iobis.org>.
- Carboneras, C., F. Jutglar, and G.M. Kirwan. 2014. Zino's Petrel (*Pterodroma madeira*). In: J. del Hoyo, A. Elliott, J. Sargatal, D.A. Christie, and E. de Juana (eds.) Handbook of the Birds of the World Alive. Lynx Edicions, Barcelona. Accessed on 28 April 2014 at <http://www.hbw.com/node/52536>.
- Carranza, A., A. Domingo, and A. Estrades. 2006. Pelagic longlines: a threat to sea turtles in the equatorial eastern Atlantic. **Biol. Conserv.** 131(1):52-57.
- Carvalho, I., C. Brito, M.E. dos Santos, and H.C. Rosenbaum. 2011. The waters of São Tomé: a calving ground for West African humpback whales? **African J. Mar. Sci.** 33(1):91-97.
- Carwardine, M. 1995. Whales, dolphins and porpoises. Dorling Kindersley Publishing, Inc., New York. 256 p.
- Castellote, M. and C. Llorens. 2013. Review of the effects of offshore seismic surveys in cetaceans: are mass strandings a possibility? Abstr. 3<sup>rd</sup> Int. Conf. Effects of Noise on Aquatic Life, Aug. 2013, Budapest, Hungary.
- Castellote, M., C.W. Clark, and M.O. Lammers. 2012. Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. **Biol. Conserv.** 147(1):115-122.
- Cato, D.H., M.J. Noad, R.A. Dunlop, R.D. McCauley, C.P. Salgado Kent, N.J. Gales, H. Kniest, J. Noad, and D. Paton. 2011. Behavioral response of Australian humpback whales to seismic surveys. **J. Acoust. Soc. Am.** 129(4):2396.

- Cato, D.H., M.J. Noad, R.A. Dunlop, R.D. McCauley, N.J. Gales, C.P. Salgado Kent, H. Kniest, D. Paton, K.C.S. Jenner, J. Noad, A.L. Maggi, I.M. Parum, and A.J. Duncan. 2012. Project BRAHSS: Behavioural response of Australian humpback whales to seismic surveys. *Proc. Austral. Acoust. Soc.*, 21–23 Nov. 2012, Fremantle, Australia. 7 p.
- Cato, D.H., M.J. Noad, R.A. Dunlop, R.D. McCauley, N.J. Gales, C.P. Salgado Kent, H. Kniest, D. Paton, K.C.S. Jenner, J. Noad, A.L. Maggi, I.M. Parum, and A.J. Duncan. 2013. A study of the behavioural response of whales to the noise of seismic air guns: design, methods and progress. **Acoust. Austral.** 41(1):88-97.
- Cauquil, P., J. Barde, C. Rodriguez, E. Chassot, and P. Chavance. 2012. Ecoscope tuna bycatch observer data. Institut de Recherche pour le Developpement (IRD). Retrieved from <http://www.iobis.org>.
- Celi, M., F. Filiciotto, D. Parrinello, G. Buscaino, M.A. Damiano, A. Cuttitta, S. D'Angelo, S. Mazzola, and M. Vazzana. 2013. Physiological and agonistic behavioural response of *Procambarus clarkii* to an acoustic stimulus. **J. Exp. Biol.** 216(4):709-718.
- Cerchio, S., S. Strindberg, T. Collins, C. Bennett, and H. Rosenbaum. 2014. Seismic surveys negatively affect humpback whale singing activity off northern Angola. **PLoS ONE** 9(3):e86464. doi:10.1371/journal.pone.0086464.
- Chiaromonte, G.E. 2005a. Argentine angelshark *Squatina argentina* (Marini, 1930). p. 232-233 *In*: S.L. Fowler, R.D. Cavanagh, M. Camhi, G.H. Burgess, G.M. Cailliet, S.V. Fordham, C.A. Simpfendorfer, and J.A. Musick (eds.) *Sharks, rays and chimaeras: the status of the Chondrichthyan fishes*. IUCN/SSC Shark Specialist Group. Accessed in June 2015 at <https://portals.iucn.org/library/efiles/documents/2005-029.pdf>.
- Chiaromonte, G.E. 2005b. Hidden angelshark *Squatina guggenheim* Marini, 1936. p. 234-236 *In*: S.L. Fowler, R.D. Cavanagh, M. Camhi, G.H. Burgess, G.M. Cailliet, S.V. Fordham, C.A. Simpfendorfer, and J.A. Musick (eds.) *Sharks, rays and chimaeras: the status of the Chondrichthyan fishes*. IUCN/SSC Shark Specialist Group. Accessed in June 2015 at <https://portals.iucn.org/library/efiles/documents/2005-029.pdf>.
- Christensen-Dalsgaard, J., C. Brandt, K.L. Willis, C. Bech Christensen, D. Ketten, P. Edds-Walton, R.R. Fay, P.T. Madsen, and C.E. Carr. 2012. Specialization for underwater hearing by the tympanic middle ear of the turtle, *Trachemys scripta elegans*. **Proc. R. Soc. B** 279(1739):2816-2824. doi: 10.1098/rspb.2012.0290.
- Clapham, P.J. 2009. Humpback whale *Megaptera novaeangliae*. p. 582-585 *In*: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), *Encyclopedia of marine mammals*, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Clark, C.W. and G.C. Gagnon. 2006. Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. Working Pap. SC/58/E9. Int. Whal. Comm., Cambridge, U.K. 9 p.
- Clark, C.W., W.T. Ellison, B.L. Southall, L. Hatch, S.M. Van Parijs, A. Frankel, and D. Ponirakis. 2009. Acoustic masking in marine ecosystems: intuitions, analysis, and implication. **Mar. Ecol. Prog. Ser.** 395:201-222.
- Clarke, M. and N. Goodall. 1994. Cephalopods in the diets of three odontocete cetacean species stranded at Tierra del Fuego, *Globicephala melaena* (Traill, 1809), *Hyperoodon planifrons* Flower, 1882 and *Cephalorhynchus commersonii* (Lacepede, 1804). **Antarct. Sci.** 6(2):149-154.
- Clark, M.R., V.I. Vinichenko, J.D.M. Gordon, G.Z. Beck-Bulat, N.N. Kukharev, and A. Kakora. 2007. Large-scale distant-water trawl fisheries on seamounts. p. 361-412 *In*: T.J. Pitcher, T. Morato, P.J.B. Hart, M.R. Clark, N. Haggan, and R.S. Santos (eds.), *Seamounts: ecology, fisheries and conservation*. Fish and Aquatic Resources Series 12. Blackwell Publishing, Oxford, U.K. 552 p.
- Clingham, E., L. Henry, and A. Beard. 2013. Monitoring population size of St. Helena cetaceans. EMD Environmental Management Division. Accessed in June 2015 at <http://www.sainthelena.gov.sh/wp-content/uploads/2012/08/EMD-Cetaceans-2013.pdf>.

- Coggon, R., G. Christeson, M. Leckie, B. Reese, D. Teagle, N. Hayman, J. Sylvan, J. Zachos, D. Sumy, B. Briggs, C. Heil, M. Huber, B. Reece, W. Gilhooly, J. Reece, S. Rausch, J. Kirkpatrick, and M. Harris. 2014. A multidisciplinary IODP investigation along a crustal flow-line across the western flank of the southern Mid-Atlantic Ridge: the South Atlantic transect. 3 p. Accessed in June 2015 at [http://www.iodp.org/doc\\_download/3988-853-precoggon-cover](http://www.iodp.org/doc_download/3988-853-precoggon-cover).
- Colonello, J.H., L.O. Lucifora, and A.M. Massa. 2007. Reproduction of the angular angel shark (*Squatina guggeneheim*): geographic differences, reproductive cycle, and sexual dimorphism. **ICES J. Mar. Sci.** 64(1):131-140.
- Compagno, L.J.V. 1984a. Vol. 4: Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2. Carcharhiniformes. FAO species catalogue. FAO Fish. Synop. 125(4/2). UNDP/FAO, Rome. Accessed in May 2015 at <http://www.fao.org/docrep/009/ad123e/ad123e00.htm>.
- Compagno, L.J.V. 1984b. Vol. 4: Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 1—Hexanchiformes to Lamniformes. FAO species catalogue. FAO Fish. Synop. 125(4/1). UNDP/FAO, Rome. Accessed in May 2015 at <http://www.fao.org/docrep/009/ad122e/ad122e00.HTM>.
- Compagno, L.J.V. 2001. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Volume 2. Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes). FAO Species Catalogue for Fishery Purposes. No. 1, Vol. 2, Rome, FAO. 269 p. Accessed in May 2015 at <http://www.fao.org/docrep/009/x9293e/x9293e00.htm>.
- Coyne, M.S., and B.J. Godley. 2005. Satellite Tracking and Analysis Tool (STAT): an integrated system for archiving, analyzing and mapping animal tracking data. **Mar. Ecol. Prog. Ser.** 301:1-7.
- Da Silva, A.C.C.D., J.C. de Castilhos, G.G. Lopez, and P.C.R. Barata. 2007. Nesting biology and conservation of olive ridley sea turtle (*Lepidochelys olivacea*) in Brazil, 1991/1992 to 2002/2003. **J. Mar. Biol. Ass. U.K.** 87(4):1047-1056.
- Dalebout, M.L., K.G. Russell, M.J. Little, and P. Ensor. 2004. Observations of live Gray's beaked whales (*Mesoplodon grayi*) in Mahurangi Harbour, North Island, New Zealand, with a summary of at-sea sightings. **J. Roy. Soc. New Zeal.** 34(4):347-356.
- Dalla Rosa, L. and E.R. Secchi. 2007. Killer whale (*Orcinus orca*) interactions with the tuna and swordfish longline fishery off southern and south-eastern Brazil: a comparison with shark interactions. **J. Mar. Biol. Ass. U.K.** 87(1):135-140.
- Darling, J.D. and R.S. Sousa-Lima. 2005. Songs indicate interaction between humpback whales (*Megaptera novaeangliae*) populations in the western and eastern South Atlantic Ocean. **Mar. Mamm. Sci.** 21(3):557-566.
- Davis, R.W., G.S. Fargion, N. May, T.D. Leming, M. Baumgartner, W.E. Evans, L.J. Hansen, and K. Mullin. 1998. Physical habitat of cetaceans along the continental slope in the north-central and western Gulf of Mexico. **Mar. Mamm. Sci.** 14(3):490-507.
- Davis, R.W., J.G. Ortega-Ortiz, C.A. Ribic, W.E. Evans, D.C. Biggs, P.H. Ressler, R.B. Cady, R.R. Lebed, K.D. Mullin, and B. Würsig. 2002. Cetacean habitat in the northern oceanic Gulf of Mexico. **Deep-Sea Res.** 49(1):21-142.
- de Boer, M.N. 2010. Cetacean distribution and relative abundance in offshore Gabonese waters. **J. Mar. Biol. Assoc. U.K.** 90(8):1613-1621.
- de Oliveira Santos, M.C., E. Zampirolli, A.F.V. Vicente, and F. Alvarenga. 2003. A Gervais' beaked whale (*Mesoplodon europaeus*) washed ashore in southeastern Brazil: extralimital record? **Aquat. Mamm.** 29(3):404-410.

- de Oliveira Santos, M.C., S. Siciliano, A.F. de Castro Vicente, F.S. Alvarenga, É. Zampirolli, S.P. de Souza, and A. Maranhão. 2010. Cetacean records along São Paulo state coast, southeastern Brazil. **Braz. J. Oceanog.** 58(2):123-142.
- de Souza, S.P., S. Siciliano, S. Cuenca, and B. de Sanctis. 2005. A True's beaked whale (*Mesoplodon mirus*) on the coast of Brazil: adding a new beaked whale species of the western tropical Atlantic and South America. **LAJAM** 4(2):129-136.
- Deem, S.L., F. Boussamba, A.Z. Nguema, G.-P. Sounguet, S. Bourgeois, J. Cianciolo, and A. Formia. 2007. Artificial lights as a significant cause of morbidity of leatherback sea turtles in Pongara National Park, Gabon. **Mar. Turtle Newsl.** 116:15-17.
- Deng, Z.D., B.L. Southall, T.J. Carlson, J. Xu, J.J. Martinez, M.A. Weiland, and J.M. Ingraham. 2014. 200-kHz commercial sonar systems generate lower frequency side lobes audible to some marine mammals. **PLoS ONE** 9(4):e95315. doi:10.1371/journal.pone.0095315.
- DeRuiter, S.L. and K.L. Doukara. 2012. Loggerhead turtles dive in response to airgun sound exposure. **Endang. Species Res.** 16(1):55-63.
- DeRuiter, S.L., I.L. Boyd, D.E. Claridge, C.W. Clark, C. Gagnon, B.L. Southall, and P.L. Tyack. 2013a. Delphinid whistle production and call matching during playback of simulated military sonar. **Mar. Mamm. Sci.** 29(2):E46-E59.
- DeRuiter, S.L., B.L. Southall, J. Calambokidis, W.M.X. Zimmer, D. Sadykova, E.A. Falcone, A.S. Friedlaender, J.E. Joseph, D. Moretti, G.S. Schorr, L. Thomas, and P.L. Tyack. 2013b. First direct measurements of behavioural responses by Cuvier's beaked whales to mid-frequency active sonar. **Biol. Lett.** 9:20130223. doi:10.1098/rsbl.2013.0223.
- de Soto, N.A., N. Delorme, J. Atkins, S. Howard, J. Williams, and M. Johnson. 2013. Anthropogenic noise causes body malformations and delays development in marine larvae. Abstr. 3<sup>rd</sup> Int. Conf. Effects of Noise on Aquatic Life, Aug. 2013, Budapest, Hungary.
- Di Benedetto, A.P.M. 2003. Interactions between gillnet fisheries and small cetaceans in northern Rio de Janeiro, Brazil: 2001–2002. **Lat. Am. J. Aquatic Mamm.** 2(2):79-86.
- Di Benedetto, A.P.M., R.M.A. Ramos, and N.R.W. Lima. 1998. Fishing activity in northern Rio de Janeiro state (Brazil) and its relation with small cetaceans. **Braz. Arch. Biol. Tech.** 41(3):296-302.
- Di Iorio, L. and C.W. Clark. 2010. Exposure to seismic survey alters blue whale acoustic communication. **Biol. Lett.** 6(1):51-54.
- Diebold, J.B., M. Tolstoy, L. Doermann, S.L. Nooner, S.C. Webb, and T.J. Crone. 2010. R/V *Marcus G. Langseth* seismic source: modeling and calibration. **Geochem. Geophys. Geosyst.** 11(12):Q12012. doi:10.1029/2010GC003126. 20 p.
- Dodd, C.K. Jr. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). U.S. Fish Wildl. Serv., **Biol. Rep.** 88(14). 110 p.
- Dolar, M.L.L. 2009. Fraser's dolphin *Lagenodelphis hosei*. p. 469-471 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Donahue, M.A. and W.L. Perryman. 2009. Pygmy killer whale, *Feresa attenuata*. p. 938-939 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Dotinga, H. and E.J. Molenaar. 2008. The Mid-Atlantic Ridge: a case study on the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction. Marine Series No. 3. IUCN, Gland, Switzerland. 22 p. Accessed in June 2015 at [http://cmsdata.iucn.org/downloads/iucn\\_marine\\_paper\\_3.pdf](http://cmsdata.iucn.org/downloads/iucn_marine_paper_3.pdf).

- Dutton, P.H., S.E. Roden, K.R. Stewart, E. LaCasella, M. Tiwari, A. Formia, J.C. Thomé, S.R. Livingstone, S. Eckert, D. Chacón-Chaverri, P. Rivalan, and P. Allman. 2013. Population stock structure of leatherback turtles (*Dermochelys coriacea*) in the Atlantic revealed using mtDNA and microsatellite markers. **Conserv. Genet.** 14(3):625-636.
- Dyndo, M., D.M. Wisniewska, L. Rojano-Doñate, and P.T. Madsen. 2015. Harbour porpoises react to low levels of high frequency vessel noise. **Sci. Rep.** 5:11083. doi:10.1038/srep11083.
- Eckert, K.L. 1995. Hawksbill sea turtle, *Eretmochelys imbricata*. p. 76-108 In: Plotkin, P.T. (ed.), National Marine Fisheries Service and U.S. Fish and Wildlife Service status reviews of sea turtles listed under the Endangered Species Act of 1973. Nat. Mar. Fish. Serv., Silver Spring, MD. 139 p.
- Eckert, K.L., B.P. Wallace, J.G. Frazier, S.A. Eckert, and P.C.H. Pritchard. 2012. Synopsis of the biological data on the leatherback sea turtle (*Dermochelys coriacea*). U.S. Department of Interior, Fish and Wildlife Service, Biol. Tech. Publ. BTP-R4015-2012, Washington, DC.
- Ellison, W.T., B.L. Southall, C.W. Clark, and A.S. Frankel. 2012. A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. **Conserv. Biol.** 26(1):21-28.
- Engel, M.H. and A.R. Martin. 2009. Feeding grounds of the western South Atlantic humpback whale population. 2009. **Mar. Mamm. Sci.** 25(4):964-969.
- Engel, M.H., M.C.C. Marcondes, C.C.A. Martins, F.O. Luna, R.P. Lima, and A. Campos. 2004. Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil. Working Pap. SC/56/E28. Int. Whal. Comm., Cambridge, U.K. 8 p.
- Engel, M.H., N.J.R. Fagundes, H.C. Rosenbaum, M.S. Leslie, P.H. Ott, R. Schmitt, E. Secchi, L. Dalla Rosa, and S.L. Bonatto. 2008. Mitochondrial DNA diversity of the Southwestern Atlantic humpback whale (*Megaptera novaeangliae*) breeding area off Brazil, and the potential connections to Antarctic feeding areas. **Conserv. Genet.** 9(5):1253-1262.
- EOL (Encyclopedia of Life). 2015. Global access to knowledge about life on Earth. Accessed in April 2015 at <http://eol.org/>.
- Evans, P.G.H. 1987. The natural history of whales and dolphins. Christopher Helm, Bromley, Kent, U.K. 343 p.
- Evans, W.E. 1994. Common dolphin, white-bellied porpoise *Delphinus delphis* Linnaeus, 1758. p. 191-224 In: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 5: The first book of dolphins. Academic Press, San Diego, CA. 416 p.
- EVOTIS. 2015. Tracking southern right whales in Península Valdés, Argentina. Accessed on 1 June 2015 at <http://www.evotis.org/southern-right-whale-tracking/>.
- FAO (Food and Agriculture Organization). 2009. International guidelines for the management of deep-sea fisheries in the high seas. Rome. 73 p. Accessed in April 2015 at <http://www.fao.org/fishery/topic/166308/en>.
- FAO (Food and Agriculture Organization). 2014a. Fishery and aquaculture statistics. Southeast Atlantic (Fishing Area 47) capture production 1975–2012 (FishstatJ). In: FAO Fisheries and Aquaculture Department (online or CD-ROM). Rome. Updated 2014. Accessed in April 2015 at <http://www.fao.org/fishery/statistics/software/fishstatj/en>.
- FAO (Food and Agriculture Organization). 2014b. Fishery and aquaculture statistics. Global capture production 1950–2012 (FishStatJ). In: FAO Fisheries and Aquaculture Department (online or CD-ROM). Rome. Updated 2014. Accessed in April 2015 at <http://www.fao.org/fishery/statistics/software/fishstatj/en>.
- FAO (Food and Agriculture Organization). 2015a. Management of deep-seas high seas fisheries. FAO of the United Nations, Fisheries and Aquaculture Department. Accessed in April 2015 at <http://www.fao.org/fishery/topic/4450/en>.

- FAO (Food and Agriculture Organization). 2015b. Southwest Atlantic: ecosystem approach to artisanal and coastal gillnet fisheries in southern Brazil. FAO of the United Nations, Fisheries and Aquaculture Department. Accessed in April 2015 at <http://www.fao.org/fishery/topic/16560/en>.
- Fay, R.R. and A.N. Popper. 2012. Fish hearing: new perspectives from two senior bioacousticians. **Brain Behav. Evol.** 79(4):215-217.
- Ferguson, M.C., J. Barlow, P. Fiedler, S.B. Reilly, and T. Gerrodette. 2006. Spatial models of delphinid (family Delphinidae) encounter rate and group size in the eastern tropical Pacific Ocean. **Ecol. Model.** 193(3-4):645-662.
- Ferreira, J.M., de Oliveira, L.R., L. Wynen, M.N. Bester, C. Guinet, N. Moraes-Barros, F.M. Martins, M.M.C. Muelbert, I.B. Moreno, S. Siciliano, P.H. Ott, and J.S. Morgante. 2008. Multiple origins of vagrant Subantarctic fur seals: a long journey to the Brazilian coast detected by molecular markers. **Polar Biol.** 31(3):303-308.
- Fertl, D., T.A. Jefferson, I.B. Moreno, A.N. Zerbini, and K.D. Mullin. 2003. Distribution of the Clymene dolphin *Stenella clymene*. **Mamm. Rev.** 33(3):253-271.
- Fewtrell, J.L. and R.D. McCauley. 2012. Impact of air gun noise on the behaviour of marine fish and squid. **Mar. Poll. Bull.** 64(5):984-993.
- Findlay, K.P., P.B. Best, G.J.B. Ross, and V.G. Cockcroft. 1992. The distribution of small odontocete cetaceans off the coasts of South-Africa and Namibia. **S. Afr. J. Mar. Sci.** 12:237-270.
- Finneran, J.J. 2012. Auditory effects of underwater noise in odontocetes. p. 197-202 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.
- Finneran, J.J. 2015. Noise-induced hearing loss in marine mammals: a review of temporary threshold shift studies from 1996 to 2015. **J. Acoust. Soc. Am.** 138(3):1702-1726.
- Finneran, J.J. and B.K. Branstetter. 2013. Effects of noise on sound perception in marine mammals. p. 273-308 *In*: H. Brumm (ed.), Animal communication and noise. Springer Berlin, Heidelberg, Germany. 453 p.
- Finneran, J.J. and C.E. Schlundt. 2010. Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (*Tursiops truncatus*) (L). **J. Acoust. Soc. Am.** 128(2):567-570.
- Finneran, J.J. and C.E. Schlundt. 2011. Noise-induced temporary threshold shift in marine mammals. **J. Acoust. Soc. Am.** 129(4):2432. [supplemented by oral presentation at the ASA meeting, Seattle, WA, May 2011].
- Finneran, J.J. and C.E. Schlundt. 2013. Effects of fatiguing tone frequency on temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*). **J. Acoust. Soc. Am.** 133(3):1819-1826.
- Finneran, J.J., C.E. Schlundt, D.A. Carder, J.A. Clark, J.A. Young, J.B. Gaspin, and S.H. Ridgway. 2000. Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. **J. Acoust. Soc. Am.** 108(1):417-431.
- Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. **J. Acoust. Soc. Am.** 111(6):2929-2940.
- Finneran, J.J., D.A. Carder, C.E. Schlundt, and S.H. Ridgway. 2005. Temporary threshold shift in bottlenose dolphins (*Tursiops truncatus*) exposed to mid-frequency tones. **J. Acoust. Soc. Am.** 118(4):2696-2705.
- Finneran, J.J., D.A. Carder, C.E. Schlundt, and R.L. Dear. 2010a. Growth and recovery of temporary threshold shift (TTS) at 3 kHz in bottlenose dolphins (*Tursiops truncatus*). **J. Acoust. Soc. Am.** 127(5):3256-3266.
- Finneran, J.J., D.A. Carder, C.E. Schlundt, and R.L. Dear. 2010b. Temporary threshold shift in a bottlenose dolphin (*Tursiops truncatus*) exposed to intermittent tones. **J. Acoust. Soc. Am.** 127(5):3267-3272.

- Finneran, J.J., C.E. Schlundt, B.K. Branstetter, J.S. Trickey, V. Bowman, and K. Jenkins. 2015. Effects of multiple impulses from a seismic air gun on bottlenose dolphin hearing and behavior. **J. Acoust. Soc. Am.** 137(4):1634-1646.
- Fisch, F. and D. Port. 2013. New stranding record of *Ziphius cavirostris* (Cuvier, 1823) (Cetacean: Ziphiidae) at Trindade Island, Brazil. **Rev. Elect. Biol. (REB)** ISSN 1983-7682 6(3):286-291.
- FleetMon. 2015. FleetMon Explorer. Accessed in April 2015 at [https://www.fleetmon.com/live\\_tracking/fleetmon\\_explorer/popup](https://www.fleetmon.com/live_tracking/fleetmon_explorer/popup).
- Flores, P.A. de C. and A. Ximinez. 1997. Observations on the rough-toothed dolphin *Steno bredanensis* off Santa Catarina Island, southern Brazilian coast. **Biotemas** 10(1):71-79.
- Ford, J.K.B. 2009. Killer whale *Orcinus orca*. p. 650-657 In: W.F Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Forney, K.A. and J. Barlow. 1998. Seasonal patterns in the abundance and distribution of California cetaceans, 1991-1992. **Mar. Mamm. Sci.** 14(3):460-489.
- Forney, K.A. and P.R. Wade. 2006. Worldwide distribution and abundance of killer whales. p. 145-162 In: J.A. Estes, D.P. DeMaster, D.F. Doak, T.M. Williams, and R.L. Brownell (eds.), Whales, whaling and ocean ecosystems. Univ. California Press, Oakland, CA. 418 p.
- Fossette, S., M.J. Witt, P. Miller, M.A. Nalovic, D. Albareda, A.P. Almeida, A.C. Broderick, D. Chacón-Chaverri, M.S. Coyne, A. Domingo, S. Eckert, D. Evans, A. Fallabrino, S. Ferraroli, A. Formia, B. Giffoni, G.C. Hays, G. Hughes, L. Kelle, A. Leslie, M. López-Mendilaharsu, P. Luschi, L. Prodocimi, S. Rodriguez-Heredia, A. Turny, S. Verhage, and B.J. Godley. 2014. Pan-Atlantic analysis of the overlap of a highly migratory species, the leatherback turtle, with pelagic longline fisheries. **Proc. R. Soc. B** 281:20133065. <http://dx.doi.org/10.1098/rspb.2013.3065>.
- Fretey, J., A. Formia, J. Tomas, J-F. Dontaine, A. Billes, and H. Angoni. 2005. Presence, nesting and conservation of *Lepidochelys olivacea* in the Gulf of Guinea. p. 12 In: M.S. Coyne and R.D. Clark (compilers), Proc. 21<sup>st</sup> Ann. Symp. Sea Turtle Biol. Conserv. NOAA Tech. Memo. NMFS-SEFSC-528. Nat. Mar. Fish. Service, Southeast Fish. Sci. Center, Miami, FL. 368 p.
- Gailey, G., B. Würsig, and T.L. McDonald. 2007. Abundance, behavior, and movement patterns of western gray whales in relation to a 3-D seismic survey, northeast Sakhalin Island, Russia. **Environ. Monit. Assessm.** 134(1-3):75-91.
- Gales, N.J., M.L. Dalebout, and J.L. Bannister. 2002. Genetic identification and biological observation of two free-swimming beaked whales: Hector's beaked whale (*Mesoplodon hectori*, Gray, 1871), and Gray's beaked whale (*Mesoplodon grayi*, Von Haast, 1876). **Mar. Mamm. Sci.** 18(2):544-555.
- Gallardo, V.A., D. Arcos, M. Salamanca, and L. Pastene. 1983. On the occurrence of Bryde's whales (*Balaenoptera edeni*, Anderson, 1978) in an upwelling area off central Chile. **Rep. Int. Whal. Comm.** 33:481-487.
- Galli, S., P. Gaspar, S. Fossette, B. Calmettes, G.C. Hays, J.R.E. Lutjeharms, and P. Luschi. 2012. Orientation of migrating leatherback turtles in relation to ocean currents. **Anim. Behav.** 84(6):1491-1500.
- Gambell, R. 1985. Fin whale *Balaenoptera physalus* (Linnaeus, 1758). p. 171-192 In: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 3: The Sirenians and baleen whales. Academic Press, London, U.K. 362 p.
- Grandi, M.F., A.D. Buren, E.A. Crespo, N.A. García, G.M. Svendsen, and S.L. Dans. 2005. Record of a specimen of Shepherd's beaked whale (*Tasmacetus shepherdii*) from the coast of Santa Cruz, Argentina, with notes on age determination. **LAJAM** 4(2):97-100.

- Gannier, A. and J. Epinat. 2008. Cuvier's beaked whale distribution in the Mediterranean Sea: results from small boat surveys 1996–2007. **J. Mar. Biol. Assoc. U.K.** 88(6):1245-1251.
- Garibaldi, L. and L. Limongelli. 2002. Trends in oceanic captures and clustering of Large Marine Ecosystems: two studies based on the FAO capture database. FAO Fisheries Tech. Pap. No. 435. Rome. 71 p. Accessed in April 2015 at <ftp://ftp.fao.org/docrep/fao/005/Y4449E/Y4449E00.pdf>.
- Garrigue, C., A. Aguayo, V.L.U. Amante-Helweg, C.S. Baker, S. Caballero, P. Clapham, R. Constantine, J. Denking, M. Donoghue, L. Flórez-González, J. Greaves, N. Hauser, C. Olavarría, C. Pairoa, H. Peckham, and M. Poole. 2002. Movements of humpback whales in Oceania, South Pacific. **J. Cetac. Res. Manage.** 4(3):255-260.
- Gedamke, J. 2011. Ocean basin scale loss of whale communication space: potential impacts of a distant seismic survey. p. 105-106 *In*: Abstr. 19<sup>th</sup> Bienn. Conf. Biol. Mar. Mamm., 27 Nov.–2 Dec. 2011, Tampa, FL. 344 p.
- Gedamke, J., N. Gales, and S. Frydman. 2011. Assessing risk of baleen whale hearing loss from seismic surveys: the effects of uncertainty and individual variation. **J. Acoust. Soc. Am.** 129(1):496-506.
- Gervaise, C., N. Roy, Y. Simard, B. Kinda, and N. Menard. 2012. Shipping noise in whale habitat: characteristics, sources, budget, and impact on belugas in Saguenay-St. Lawrence Marine Park hub. **J. Acoust. Soc. Am.** 132(1):76-89.
- Gitirana, H.M. and A.T. Souza. 2012. Notes on the spatial distribution and foraging behavior of green turtles at the Fernando de Noronha Archipelago, northeastern Brazil. **Mar. Turtle Newsl.** 132:9-12.
- Godfrey, M. and J. Chevalier. 2004. The status of olive ridley sea turtles in the west Atlantic. Unpubl. Rep. to the Marine Turtle Specialist Group of the SSC/IUCN. 22 p. Accessed in June 2015 at <http://members.seaturtle.org/godfreym/Godfrey2004MTSG.pdf>.
- Godley, B.J., E.H.S.M. Lima, S. Åkesson, A.C. Broderick, F. Glen, M.H. Godfrey, P. Luschi, and G.C. Hays. 2003. Movement patterns of green turtles in Brazilian coastal waters described by satellite tracking and flipper tagging. **Mar. Ecol. Prog. Ser.** 253:279-288.
- Goldbogen, J.A., B.L. Southall, S.L. DeRuiter, J. Calambokidis, A.S. Friedlaender, E.L. Hazen, E. Falcone, G. Schorr, A. Douglas, D.J. Moretti, C. Kyburg, M.F. McKenna, and P.L. Tyack. 2013. Blue whales respond to simulated mid-frequency military sonar. **Proc. R. Soc. B.** 280:20130657. doi:10.1098/rspb.2013.0657.
- Gong, Z., A.D. Jain, D. Tran, D.H. Yi, F. Wu, A. Zorn, P. Ratilal, and N.C. Makris. 2014. Ecosystem scale acoustic sensing reveals humpback whale behavior synchronous with herring spawning processes and re-evaluation finds no effect of sonar on humpback song occurrence in the Gulf of Maine in fall 2006. **PLoS ONE** 9(10):e104733. doi:10.1371/journal.pone.0104733.
- González Carman, V., K.C. Álvarez, L. Prosdocimi, M.C. Inchaurreaga, R.F. Dellacasa, A. Faiella, C. Echenique, R. González, J. Andrejuk, H.W. Mianzan, C. Campagna, and D. Albareda. 2011. Argentinian coastal waters: A temperate habitat for three species of threatened sea turtles. **Mar. Biol. Res.** 7(5):500-508.
- Goodall, R.N.P. 2009. Hourglass dolphin *Lagenorhynchus cruciger*. p. 573-576 *In*: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> edit. Academic Press, San Diego, CA. 1316 p.
- Goodall, R.N.P., M.C. Marchesi, L.E. Pimper, N. Dellabianca, L.G. Benegas, M.A. Torres, and L. Riccialdelli. 2011. Southernmost records of bottlenose dolphins, *Tursiops truncatus*. **Polar Biol.** 34(7):1085-1090.
- Gordon, J., D. Gillespie, J. Potter, A. Frantzis, M.P. Simmonds, R. Swift, and D. Thompson. 2004. A review of the effects of seismic surveys on marine mammals. **Mar. Technol. Soc. J.** 37(4):16-34.

- Gray, H. and K. Van Waerebeek. 2011. Postural instability and akinesia in a pantropical spotted dolphin, *Stenella attenuata*, in proximity to operating airguns of a geophysical seismic vessel. **J. Nature Conserv.** 19(6):363-367.
- Guerra, M., A.M. Thode, S.B. Blackwell, and M. Macrander. 2011. Quantifying seismic survey reverberation off the Alaskan North Slope. **J. Acoust. Soc. Am.** 130(5):3046-3058.
- Guerra, M., P.J. Dugan, D.W. Ponirakis, M. Popescu, Y. Shiu, and C.W. Clark. 2013. High-resolution analysis of seismic airgun impulses and their reverberant field as contributors to an acoustic environment. Abstr. 3<sup>rd</sup> Int. Conf. Effects of Noise on Aquatic Life, Aug. 2013, Budapest, Hungary.
- Handegard, N.O., T.V. Tronstad, and J.M. Hovem. 2013. Evaluating the effect of seismic surveys on fish—the efficacy of different exposure metrics to explain disturbance. **Can. J. Fish. Aquat. Sci.** 70(9):1271-1277.
- Hansen, L.J., K.D. Mullin, and C.L. Roden. 1994. Preliminary estimates of cetacean abundance in the northern Gulf of Mexico, and selected species in the U.S. Atlantic exclusive economic zone from vessel surveys. Miami Lab Contrib. No. MIA-93/94-58. Nat. Mar. Fish. Serv., Southeast Fish. Sci. Center, Miami, FL. 14 p.
- Hastie, G.D., C. Donovan, T. Götz, and V.M. Janik. 2014. Behavioral responses of grey seals (*Halichoerus grypus*) to high frequency sonar. **Mar. Poll. Bull.** 79(1-2):205-210.
- Hastings, M.C. and J. Miksis-Olds. 2012. Shipboard assessment of hearing sensitivity of tropical fishes immediately after exposure to seismic air gun emissions at Scott Reef. p. 239-243 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.
- Hatch, L.T., C.W. Clark, S.M. Van Parijs, A.S. Frankel, and D.W. Ponirakis. 2012. Quantifying loss of acoustic communication space for right whales in and around a U.S. National Marine Sanctuary. **Conserv. Biol.** 26(6):983-994.
- Hawkins, A.D., A.E. Pembroke, and A.N. Popper. 2015. Information gaps in understanding the effects of noise on fishes and invertebrates. **Rev. Fish Biol. Fisher.** 25(1):39-64. doi:10.1007/s11160-014-9369-3.
- Hays, G.C., A.C. Broderick, B.J. Godley, P. Lovell, C. Martin, B.J. McConnell, and S. Richardson. 2002. Biphasal long-distance migration in green turtles. **Anim. Behav.** 64(6):895-898.
- Heide-Jørgensen, M.P., R.G. Hansen, S. Fossette, N.J. Nielsen, M.V. Jensen, and P. Hegelund. 2013a. Monitoring abundance and hunting of narwhals in Melville Bay during seismic surveys. Preliminary report from the Greenland Institute of Natural Resources. 59 p. Accessed on 13 March 2015 at [http://www.natur.gl/fileadmin/user\\_files/Dokumenter/PAFU/Monitoring\\_abundance\\_and\\_hunting\\_of\\_narwhals\\_in\\_Melville\\_Bay\\_GINR\\_Preliminary\\_report\\_endelig\\_\\_2\\_.pdf](http://www.natur.gl/fileadmin/user_files/Dokumenter/PAFU/Monitoring_abundance_and_hunting_of_narwhals_in_Melville_Bay_GINR_Preliminary_report_endelig__2_.pdf).
- Heide-Jørgensen, M.P., R.G. Hansen, K. Westdal, R.R. Reeves, and A. Mosbech. 2013b. Narwhals and seismic exploration: is seismic noise increasing the risk of ice entrapments? **Biol. Conserv.** 158:50-54.
- Hermanssen, L., J. Tougaard, K. Beedholm, J. Nabe-Nielsen, and P.T. Madsen. 2014. High frequency components of ship noise in shallow water with a discussion of implications for harbor porpoises (*Phocoena phocoena*). **J. Acoust. Soc. Am.** 136(4):1640-1653.
- Hermanssen, L., K. Beedholm, J. Tougaard, and P.T. Madsen. 2015. Characteristics and propagation of airgun pulses in shallow water with implications for effects on small marine mammals. **PLoS ONE** 10(7):e0133436. doi:10.1371/journal.pone.0133436.
- Heyning, J.E. 1989. Cuvier's beaked whale *Ziphius cavirostris* G. Cuvier, 1823. p. 289-308 *In*: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales. Academic Press, San Diego, CA. 444 p.
- Heyning, J.E. and M.E. Dalheim. 1988. *Orcinus orca*. **Mammal. Spec.** 304:1-9.

- Hindell, M.A. and W.F. Perrin. 2009. Elephant seals *Mirounga angustirostris* and *M. leonine*. p. 364-368 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> edit. Academic Press, San Diego, CA. 1316 p.
- Hochscheid, S., F. Bentivegna, M.N. Bradai, and G.C. Hays. 2007. Overwintering behaviour in sea turtles: dormancy is optional. **Mar. Ecol. Prog. Ser.** 340:287-298.
- Hofmeyr, G.J.G., M.N. Bester, and F.C. Jonker. 1997. Changes in population sizes and distribution of fur seals at Marion island. **Polar Biol.** 17(2):150-158.
- Holt, M.M., D.P. Noren, R.C. Dunkin, and T.M. Williams. 2015. Vocal performance affects metabolic rate in dolphins: implications for animals communicating in noisy environments. **J. Exp. Biol.** 218(11):1647-1654. doi:10.1242/jeb.122424.
- Horwood, J. 2009. Sei whale *Balaenoptera borealis*. p. 1001-1003 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Hovem, J.M., T.V. Tronstad, H.E. Karlsen, and S. Løkkeborg. 2012. Modeling propagation of seismic airgun sounds and the effects on fish behaviour. **IEEE J. Ocean. Eng.** 37(4):576-588.
- Hoyt, E. 2011. Marine protected areas for whales, dolphins and porpoises: A world handbook for cetacean habitat conservation and planning, 2<sup>nd</sup> ed. Earthscan, London, U.K., and New York, NY. 464 p.
- Huang, R.X. and X. Jin. 2002. Deep circulation in the South Atlantic induced by bottom-intensified mixing over the mid-ocean ridge. **J. Phys. Oceanog.** 32(4):1150-1164.
- Iniíguez, M., J.F. Masello, C. Gribaudo, D. Arcucci, F. Krohling, and J. Belgrano. 2010. On the occurrence of sei whales, *Balaenoptera borealis*, in the south-western Atlantic. **Mar. Biodiv. Rec** 3:e68. doi:10.1017/S1755267210000576.
- IODP (International Ocean Discovery Program). 2014. Borehole KML file. Accessed in May 2015 at <http://www.iodp.org/borehole-map>.
- IUCN (International Union for Conservation of Nature). 2015. The IUCN Red List of Threatened Species. Version 2015.2. Accessed in July 2015 at <http://www.iucnredlist.org>.
- IWC (International Whaling Commission). 1981. Report of the subcommittee on other baleen whales. **Rep. Int. Whal. Comm.** 31:122-132.
- IWC (International Whaling Commission). 2001. Report of the workshop on the comprehensive assessment of right whales: a worldwide comparison. **J. Cetac. Res. Manage. Spec. Iss.** 2:1-60.
- IWC (International Whaling Commission). 2007. Report of the standing working group on environmental concerns. Annex K to Report of the Scientific Committee. **J. Cetac. Res. Manage.** 9(Suppl.):227-260.
- IWC (International Whaling Commission). 2014. Satellite tagging to help solve the puzzle of southern right whale die-off in Patagonia. Accessed on 12 May 2015 at <https://iwc.int/satellite-tagging-to-help-understand-southern-right>.
- IWC (International Whaling Commission). 2015a. Whale sanctuaries. Accessed in May 2015 at <https://iwc.int/sanctuaries>.
- IWC (International Whaling Commission). 2015b. Whale population estimates. Accessed on 12 May 2015 at <http://iwc.int/estimate>.
- Jackson, J.A., D.J. Steel, P. Beerli, B.C. Congdon, C. Olavarria, M.S. Leslie, C. Pomilla, H. Rosenbaum, and C.S. Baker. 2014. Global diversity and oceanic divergence of humpback whales (*Megaptera novaeangliae*). *Proc. R. Soc. B* 281:20133222. <http://dx.doi.org/10.1098/rspb.2013.3222>.

- Jaquet, N. and H. Whitehead. 1996. Scale-dependent correlation of sperm whale distribution with environmental features and productivity in the South Pacific. **Mar. Ecol. Prog. Ser.** 135:1-9.
- Jaquet, N. and D. Gendron. 2002. Distribution and relative abundance of sperm whales in relation to key environmental features, squid landings and the distribution of other cetacean species in the Gulf of California, Mexico. **Mar. Biol.** 141(3):591-601.
- Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine mammals of the world: a comprehensive guide to their identification. Elsevier, London, U.K. 573 p.
- Jensen, F.H., L. Bejder, M. Wahlberg, N. Aguilar Soto, M. Johnson, and P.T. Madsen. 2009. Vessel noise effects on delphinid communication. **Mar. Ecol. Prog. Ser.** 395:161-175.
- Johnson, S.R., W.J. Richardson, S.B. Yazvenko, S.A. Blokhin, G. Gailey, M.R. Jenkerson, S.K. Meier, H.R. Melton, M.W. Newcomer, A.S. Perlov, S.A. Rutenko, B. Würsig, C.R. Martin, and D.E. Egging. 2007. A western gray whale mitigation and monitoring program for a 3-D seismic survey, Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):1-19.
- Kasamatsu, F. and G.G. Joyce. 1995. Current status of odontocetes in the Antarctic. **Antarct. Sci.** 7(4):365-379.
- Kastak, D. and C. Reichmuth. 2007. Onset, growth, and recovery of in-air temporary threshold shift in a California sea lion (*Zalophus californianus*). **J. Acoust. Soc. Am.** 122(5):2916-2924.
- Kastak, D., R.L. Schusterman, B.L. Southall, and C.J. Reichmuth. 1999. Underwater temporary threshold shift induced by octave-band noise in three species of pinnipeds. **J. Acoust. Soc. Am.** 106(2):1142-1148.
- Kastak, D., B.L. Southall, R.J. Schusterman, and C. Reichmuth. 2005. Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. **J. Acoust. Soc. Am.** 118(5):3154-3163.
- Kastak, D., J. Mulsow, A. Ghoul, and C. Reichmuth. 2008. Noise-induced permanent threshold shift in a harbor seal. **J. Acoust. Soc. Am.** 123(5):2986.
- Kastelein, R., R. Gransier, L. Hoek, and J. Olthuis. 2012a. Temporary threshold shifts and recovery in a harbor porpoise (*Phocoena phocoena*) after octave-band noise at 4 kHz. **J. Acoust. Soc. Am.** 132(5):3525-3537.
- Kastelein, R.A., R. Gransier, L. Hoek, A. Macleod, and J.M. Terhune. 2012b. Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. **J. Acoust. Soc. Am.** 132(4):2745-2761.
- Kastelein, R.A., N. Steen, R. Gransier, and C.A.F. de Jong. 2013a. Brief behavioral response threshold level of a harbor porpoise (*Phocoena phocoena*) to an impulsive sound. **Aquat. Mamm.** 39(4):315-323.
- Kastelein, R.A., R. Gransier, and L. Hoek, and M. Rambags. 2013b. Hearing frequency thresholds of a harbour porpoise (*Phocoena phocoena*) temporarily affected by a continuous 1.5-kHz tone. **J. Acoust. Soc. Am.** 134(3):2286-2292.
- Kastelein, R., R. Gransier, and L. Hoek. 2013c. Comparative temporary threshold shifts in a harbour porpoise and harbour seal, and severe shift in a seal (L). **J. Acoust. Soc. Am.** 134(1):13-16.
- Kastelein, R.A., L. Hoek, R. Gransier, M. Rambags, and N. Clayes. 2014. Effect of level, duration, and inter-pulse interval of 1–2 kHz sonar signal exposures on harbor porpoise hearing. **J. Acoust. Soc. Am.** 136:412-422.
- Kastelein, R.A., R. Gransier, J. Schop, and L. Hoek. 2015a. Effects of exposure to intermittent and continuous 6–7 kHz sonar sweeps on harbor porpoise (*Phocoena phocoena*) hearing. **J. Acoust. Soc. Am.** 137(4):1623-1633.
- Kastelein, R.A., R. Gransier, M.A.T. Marijt, and L. Hoek. 2015b. Hearing frequency thresholds of harbor porpoises (*Phocoena phocoena*) temporarily affected by played back offshore pile driving sounds. **J. Acoust. Soc. Am.** 137(2):556-564.

- Kasuya, T. 1986. Distribution and behavior of Baird's beaked whales off the Pacific coast of Japan. **Sci. Rep. Whales Res. Inst.** 37:61-83.
- Kasuya, T. 2009. Giant beaked whales *Berardius bairdii* and *B. arnuxii*. p. 498-500 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> edit. Academic Press, San Diego, CA. 1316 p.
- Kato, H. and W.F. Perrin. 2009. Bryde's whales *Balaenoptera edeni/brydei*. p. 158-163 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Katos, J.E., S. dos Santos, V.G. de Azevedo, B.M. Gallo, and P.C. Parata. 2004. Incidental capture of loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) sea turtles by the pelagic longline fishery off southern Brazil. **Fish. Bull.** 102(2):393-399.
- Kemper, C.M. 2002. Distribution of the pygmy right whale, *Caperea marginata*, in the Australasian region. **Mar. Mamm. Sci.** 18(1):99-111.
- Kemper, C.M. 2009. Pygmy right whale *Caperea marginata*. p. 939-941 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> edit. Academic Press, San Diego, CA. 1316 p.
- Kenney, R.D. 2009. Right whales *Eubalaena glacialis*, *E. japonica*, and *E. australis*. p. 962-972 In: W.F. Perrin, B. Würsig, and J. G. M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> edit. Academic Press, San Diego, CA. 1316 p.
- Ketten, D.R. 2012. Marine mammal auditory system noise impacts: evidence and incidence. p. 207-212 In: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.
- Ketten, D.R., J. O'Malley, P.W.B. Moore, S. Ridgway, and C. Merigo. 2001. Aging, injury, disease, and noise in marine mammal ears. **J. Acoust. Soc. Am.** 110(5, Pt. 2):2721 (Abstract).
- Klinck, H., S.L. Nieukirk, D.K. Mellinger, K. Klinck, H. Matsumoto, and R.P. Dziak. 2012. Seasonal presence of cetaceans and ambient noise levels in polar waters of the North Atlantic. **J. Acoust. Soc. Am.** 132(3):EL176-EL181.
- Knight, R. and J. Westwood. 1999. Long-term prospects very bright for deep waters off West Africa. Oil & Gas Journal. Accessed in May 2015 at <http://www.ogj.com/articles/print/volume-97/issue-3/in-this-issue/general-interest/long-term-prospects-very-bright-for-deep-waters-off-west-africa.html>.
- Koch, A.L., A. Carr, and D.W. Ehrenfeld. 1969. The problem of open-sea navigation: the migration of the green turtle to Ascension Island. **J. Theoret. Biol.** 22(1):163-179.
- Kotas, J.E. 2005. Scalloped hammerhead *Sphyrna lewini* (Griffith & Smith, in Cuvier, Griffith & Smith, 1834). p. 314-316 In: S.L. Fowler, R.D. Cavanagh, M. Camhi, G.H. Burgess, G.M. Cailliet, S.V. Fordham, C.A. Simpfendorfer, and J.A. Musick (eds.), Sharks, rays and chimaeras: the status of the Chondrichthyan fishes. IUCN/SSC Shark Specialist Group. Accessed in June 2015 at <https://portals.iucn.org/library/efiles/documents/2005-029.pdf>.
- Krieger, K.J. and B.L. Wing. 1984. Hydroacoustic surveys and identification of humpback whale forage in Glacier Bay, Stephens Passage, and Frederick Sound, southeastern Alaska, summer 1983. NOAA Tech. Memo. NMFS F/NWC-66. Nat. Mar. Fish. Serv., Auke Bay, AK. 60 p. NTIS PB85-183887.
- Krieger, K.J. and B.L. Wing. 1986. Hydroacoustic monitoring of prey to determine humpback whale movements. NOAA Tech. Memo. NMFS F/NWC-98. Nat. Mar. Fish. Serv., Auke Bay, AK. 63 p. NTIS PB86-204054.
- Laporta, P., R. Praderi, V. Little, and A. Le Bas. 2005. An Andrew's beaked whale *Mesoplodon bowdoini* (Cetacean, Ziphiidae) stranded on the Atlantic coast of Uruguay. **LAJAM** 4(2):101-111.

- Lavender, A.L., S.M. Bartol, and I.K. Bartol. 2014. Ontogenetic investigation of underwater hearing capabilities in loggerhead sea turtles (*Caretta caretta*) using a dual testing approach. **J. Exp. Biol.** 217(14):2580-2589.
- Laws, R. 2012. Cetacean hearing-damage zones around a seismic source. p. 473-476 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.
- Le Prell, C.G. 2012. Noise-induced hearing loss: from animal models to human trials. p. 191-195 *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.
- Lemke, D., J.G. Frazier, J.C.A. Thomé, A.P. Almeida, J. Scalfoni. 2006. Satellite telemetry of loggerheads in Brazil. p. 230-233 *In*: N.J. Pilcher (compiler), Proc. 23<sup>rd</sup> Ann. Symp. Sea Turtle Biol. Conserv. NOAA Tech. Memo. 536. Nat. Mar. Fish. Service, Southeast Fish. Sci. Center, Miami, FL. 261 p. Accessed in October 2015 at [http://www.sefsc.noaa.gov/turtles/TM\\_536\\_Pilcher\\_23.pdf](http://www.sefsc.noaa.gov/turtles/TM_536_Pilcher_23.pdf).
- Lenhardt, M. 2002. Sea turtle auditory behavior. **J. Acoust. Soc. Amer.** 112(5, Pt. 2):2314 (Abstract).
- Lessa, R. and C.M. Vooren. 2005. Brazilian guitarfish *Rhinobatos horkelii* Müller & Henle, 1841. p. 329-331 *In*: S.L. Fowler, R.D. Cavanagh, M. Camhi, G.H. Burgess, G.M. Cailliet, S.V. Fordham, C.A. Simpfendorfer, and J.A. Musick (eds.) Sharks, rays and chimaeras: the status of the Chondrichthyan fishes. IUCN/SSC Shark Specialist Group. Accessed in June 2015 at <https://portals.iucn.org/library/efiles/documents/2005-029.pdf>.
- Levin, L.A. and A.J. Gooday. 2003. The deep Atlantic Ocean. p. 111-178 *In*: P.A. Tyler (ed.), Ecosystems of the Deep Oceans. Ecosystems of the World Vol. 28. Elsevier Science, Amsterdam, Netherlands. 582 p.
- Lewis, M., C. Campagna, M.R. Marin, and T. Fernandez. 2006a. Southern elephant seals north of the Antarctic Polar Front. **Antarct. Sci.** 18(2):213-221.
- Lewis, M.N., C. Campagna, and M.R. Marin. 2006b. Distribution ashore and breeding places of southern elephant seals in South America. *In*: Distribution of elephant seals. Mirtha Lewis, Centro Nacional Patagónico, Puerto Madryn, Argentina. Retrieved from <http://www.iobis.org>.
- Lewison, R.L., S.A. Freeman, and L.B. Crowder. 2004. Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles. **Ecol. Lett.** 7(3):221-231.
- Liberman, C. 2013. New perspectives on noise damage. Abstr. 3<sup>rd</sup> Int. Conf. Effects of Noise on Aquatic Life, Aug. 2013, Budapest, Hungary.
- Lima, E.H.S.M., M.T.D. Melo, A.S. Santos, A.A. Arenas, and M.H. Godfrey. 2014. Second record of tagged loggerhead moving between South and North Atlantic. **Mar. Turtle Newsl.** 143:16.
- Linden, W. 1980. Walvis Ridge, a piece of Africa? **Geology** 8(9):417-421.
- Lipsky, J.D. 2009. Right whale dolphins *Lissodelphis borealis*, *L. peronii*. p. 958-962 *In*: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Llido, J., V. Garçon, J.R.E. Lutjeharms, and J. Sudre. 2005. Event-scale blooms drive enhanced primary productivity at the Subtropical Convergence. **Geophys. Res. Lett.** 32(15):L15611. Doi:10.1029/2005GL022880.
- Longhurst, A. 2007. Ecological geography of the sea, 2<sup>nd</sup> ed. Elsevier Academic Press, San Diego, CA. 542 p.
- López-Barrera, E.A., G.O. Longo, and E.L.A. Monteiro-Filho. 2012. Incidental capture of green turtle (*Chelonia mydas*) in gillnets of small-scale fisheries in the Paranaguá Bay, Southern Brazil. **Ocean Coast. Manage.** 60:11-18.
- Løkkeborg, S., E. Ona, A. Vold, and A. Saltehaug. 2012. Sounds from seismic air guns: gear- and species-specific effects on catch rates and fish distribution. **Can. J. Fish. Aquat. Sci.** 69(8):1278-1291.

- Lucke, K., U. Siebert, P.A. Lepper, and M.A. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. **J. Acoust. Soc. Am.** 125(6):4060-4070.
- Luís, A.R., M.N. Couchinho, and M.E. Dos Santos. 2014. Changes in the acoustic behavior of resident bottlenose dolphins near operating vessels. 2014. **Mar. Mamm. Sci.** 30(4):1417-1426.
- Lurton, X. 2015. Modelling of the sound field radiated by multibeam echosounders for acoustical impact assessment. **Appl. Acoust.** 101:201-216.
- Luschi, P., G.C. Hays, C. Del Seppia, R. Marsh, and F. Papi. 1998. The navigation feats of green sea turtles migration from Ascension Island investigated by satellite telemetry. **Proc. R. Soc. B** 265(1412):2279-2284.
- Lusseau, D. and L. Bejder. 2007. The long-term consequences of short-term responses to disturbance experience from whalewatching impact assessment. **Int. J. Comp. Psych.** 20(2-3):228-236.
- MacGillivray, A.O., R. Racca, and Z. Li. 2014. Marine mammal audibility of selected shallow-water survey sources. **J. Acoust. Soc. Am.** 135(1):EL35-EL40.
- MacLeod, C.D. and E. Bennett. 2007. Pan-tropical spotted dolphins (*Stenella attenuata*) and other cetaceans around St Helena in the tropical south-eastern Atlantic. **J. Mar. Biol. Ass. U.K.** 87(1):339-344.
- MacLeod, C.D. and G. Mitchell. 2006. Key areas for beaked whales worldwide. **J. Cetac. Res. Manage.** 7(3):309-322.
- MacLeod, C.D., N. Hauser, and H. Peckham. 2004. Diversity, relative density and structure of the cetacean community in summer months east of Great Abaco, Bahamas. **J. Mar. Biol. Assoc. U.K.** 84(2):469-474.
- MacLeod, C.D., W.F. Perrin, R. Pitman, J. Barlow, L.T. Ballance, A. D'Amico, T. Gerrodette, G. Joyce, K.D. Mullin, D. Palka, and G.T. Waring. 2006. Known and inferred distributions of beaked whale species (Cetacea: Ziphiidae). **J. Cetac. Res. Manage.** 7(3):271-286.
- Maguire, J.-J., M. Sissenwine, J. Csirke, R. Grainger, and S. Garcia. 2006. The state of world highly migratory, straddling and other high seas fisheries resources and associated species. FAO Fisheries Tech. Pap. No. 495. FAO, Rome. 84 p. Accessed in June 2015 at <http://www.fao.org/docrep/009/a0653e/a0653e00.htm>.
- Malme, C.I. and P.R. Miles. 1985. Behavioral responses of marine mammals (gray whales) to seismic discharges. p. 253-280 *In*: G.D. Greene, F.R. Engelhard, and R.J. Paterson (eds.), Proc. Workshop on Effects of Explosives Use in the Marine Environment, Jan. 1985, Halifax, NS. Tech. Rep. 5. Can. Oil & Gas Lands Admin., Environ. Prot. Br., Ottawa, Ont. 398 p.
- Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack, and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. BBN Rep. 5586. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for MMS, Alaska OCS Region, Anchorage, AK. NTIS PB86-218377.
- Malme, C.I., P.R. Miles, P. Tyack, C.W. Clark, and J.E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding humpback whale behavior. BBN Rep. 5851. OCS Study MMS 85-0019. Rep. from BBN Labs Inc., Cambridge, MA, for MMS, Anchorage, AK. NTIS PB86-218385.
- Malme, C.I., B. Würsig, J.E. Bird, and P. Tyack. 1986. Behavioral responses of gray whales to industrial noise: feeding observations and predictive modeling. BBN Rep. 6265. OCS Study MMS 88-0048. Outer Contin. Shelf Environ. Assess. Progr., Final Rep. Princ. Invest., NOAA, Anchorage, AK. 56(1988):393-600. NTIS PB88-249008.
- Malme, C.I., B. Würsig, B., J.E. Bird, and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. p. 55-73 *In*: W.M. Sackinger, M.O. Jeffries, J.L. Imm, and S.D. Treacy

- (eds.), Port and Ocean Engineering Under Arctic Conditions Vol. II. Symposium on noise and marine mammals. Univ. Alaska Fairbanks, Fairbanks, AK. 111 p.
- Marcovaldi, M.A. 2001. Status and distribution of the olive ridley turtle, *Lepidochelys olivacea*, in the western Atlantic Ocean. p. 52-56 In: K.L. Eckert and F. A. Abreu-Grobois (eds.), Proc. regional meeting: marine turtle conservation in the wider Caribbean region: a dialogue for effective regional management. Santo Domingo, 16–18 Nov. 1999. WIDECAST, IUCN-MTSG, WWF and UNEP-CEP.
- Marcovaldi, M.Â. and M. Chaloupka. 2007. Conservation status of the loggerhead sea turtle in Brazil: an encouraging outlook. **Endang. Spec. Res.** 3(2):133-143.
- Marcovaldi, M.Â. and A. Filippini. 2001. Trans-Atlantic movement by a juvenile hawksbill turtle. **Mar. Turtle Newsl.** 52:3.
- Marcovaldi M.A., A.C.C.D. Da Silva, B.M.G. Gallo, C. Baptistotte, E.P. Lima, C. Berllini, E.H.S.M. Lima, J.C. De Castilhos, J.C.A. Thomé, L.M. de P. Moreira, and T.M. Sanches. 2000. Recaptures of tagged turtles from nesting and feeding grounds protected by Projeto TAMARIBAMA, Brasil. p. 164-166 In: H.J. Kalb and T. Wibbels (compilers), Proc. 19<sup>th</sup> Ann. Symp. Sea Turtle Biol. Conserv. NOAA Tech Memo 443. 291 p. Accessed in June 2015 at [http://www.sefsc.noaa.gov/turtles/TM\\_443\\_Kalb\\_Wibbels\\_19.pdf](http://www.sefsc.noaa.gov/turtles/TM_443_Kalb_Wibbels_19.pdf).
- Marcovaldi, M.Â., G. Sales, J.C.A. Thomé, A.C.C. Dias da Silva, B.M.G. Gallo, E.H.S.M. Lima, E.P. Lima, and C. Bellini. 2006. Sea turtles and fishery interactions in Brazil: identifying and mitigating potential conflicts. **Mar. Turtle Newsl.** 112:4-8.
- Marcovaldi, M.Â., G.G. Lopez, L.S. Soares, A.J.B. Santos, C. Bellini, and P.C.R. Barata. 2007. Fifteen years of hawksbill sea turtle (*Eretmochelys imbricata*) nesting in northern Brazil. **Chel. Conserv. Biol.** 6(2):223-228.
- Marcovaldi, M.Â., G.G. Lopez, L.S. Soares, E.H.S.M. Lima, J.C.A. Thomé. 2010. Satellite-tracking of female loggerhead turtles highlights fidelity behavior in northeastern Brazil. **Endang. Spec. Res.** 12(3):263-272.
- Marcovaldi, M.Â., G.G. Lopez, L.S. Soares, and M. López-Mendilaharsu. 2012. Satellite tracking of hawksbill turtle *Eretmochelys imbricata* nesting in northern Bahia, Brazil: turtle movements and foraging destinations. **Endang. Spec. Res.** 17(2):123-132.
- MarineTraffic. 2015. Life Ships Map—AIS—Vessel Traffic and Positions. MarineTraffic.com. Accessed in April 2015 at <http://www.marinetraffic.com>.
- Martin, K.J., S.C. Alessi, J.C. Gaspard, A.D. Tucker, G.B. Bauer and D.A. Mann. 2012. Underwater hearing in the loggerhead turtle (*Caretta caretta*): a comparison of behavioral and auditory evoked potential audiograms. **J. Exp. Biol.** 215(17):3001-3009.
- Martins, C.C.A., M.E. Morete, M.H. Engel, A.C. Freitas, E.R. Secchi, and P.G. Kinas. 2001. Aspects of habitat use patterns of humpback whales in the Abrolhos Bank, Brazil, breeding ground. **Mem. Queensl. Mus.** 47(2):563-570.
- Mascarenhas, R., R. Santos, and D. Zeppelini. 2004. Plastic debris ingestion by sea turtle in Paraíba, Brazil. **Mar. Poll. Bull.** 49(4):354-355.
- Mate, B.R., P.B. Best, B.A. Lagerquist, and M.H. Winsor. 2011. Coastal, offshore, and migratory movements of South African right whales revealed by satellite telemetry. **Mar. Mamm. Sci.** 27(3):455-476.
- Maughan, B. 2003. United Kingdom Royal Navy cetacean sighting. Retrieved from <http://www.iobis.org>.
- Maxwell, S.M., G.A. Breed, B.A. Nickel, J. Makanga-Bahouna, E. Pemo-Makaya, R.J. Parnell, A. Formia, S. Ngouessono, B.J. Godley, D.P. Costa, M.J. Witt, and M.S. Coyne. 2011. Using satellite tracking to optimize protection of long-lived marine species: olive ridley sea turtle conservation in central Africa. **PLoS ONE** 6(5):e19905. doi:10.1371/journal.pone.0019905.

- McAlpine, D.F. 2009. Pygmy and dwarf sperm whales *Kogia breviceps* and *K. sima*. p. 936-938 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- McCauley, R.D., M.-N. Jenner, C. Jenner, K.A. McCabe, and J. Murdoch. 1998. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. **APPEA J.** 38:692-707.
- McCauley, R.D., J. Fewtrell, A.J. Duncan, C. Jenner, M.-N. Jenner, J.D. Penrose, R.I.T. Prince, A. Adhitya, J. Murdoch, and K. McCabe. 2000. Marine seismic surveys: analysis of airgun signals; and effects of air gun exposure on humpback whales, sea turtles, fishes and squid. Rep. from Centre for Marine Science and Technology, Curtin Univ., Perth, Western Australia, for Australian Petrol. Produc. & Explor. Assoc., Sydney, NSW. 188 p.
- McConnell, B.J. and M.A. Fedak. 1996. Movements of southern elephant seals. **Can. J. Zool.** 74(8):1485-1496.
- McDonald, T.L., W.J. Richardson, K.H. Kim, and S.B. Blackwell. 2010. Distribution of calling bowhead whales exposed to underwater sounds from Northstar and distant seismic surveys, 2009. p. 6-1 to 6-38 In: W.J. Richardson (ed.), Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar oil development, Alaskan Beaufort Sea: comprehensive report for 2005–2009. LGL Rep. P1133-6. Rep. from LGL Alaska Res. Assoc. Inc., Anchorage, AK, Greeneridge Sciences Inc., Santa Barbara, CA, WEST Inc., Cheyenne, WY, and Applied Sociocult. Res., Anchorage, AK, for BP Explor. (Alaska) Inc., Anchorage, AK. 265 p.
- McDonald, T.L., W.J. Richardson, K.H. Kim, S.B. Blackwell, and B. Streever. 2011. Distribution of calling bowhead whales exposed to multiple anthropogenic sound sources and comments on analytical methods. p. 199 In: Abstr. 19<sup>th</sup> Bienn. Conf. Biol. Mar. Mamm., 27 Nov.–2 Dec. 2011, Tampa, FL. 344 p.
- McDowell, S., N. Kumar, R.D. Jacobi, D.A. Johnson, and E.T. Bunce. 1977. 42. Regional setting of Site 357, north flank of Rio Grande Rise. p. 955-969 In: K. Perch-Nielsen, P.R. Supko, Y.P. Neprochnov, H.B. Zimmerman, F. McCoy, N. Kumar, J. Thiede, E. Bonatti, R. Fodor, A. Boersma, M.G. Dinkelman, and R.L. Carlson (eds.), Initial reports of the Deep Sea Drilling Project, Vol. 39. Washington, U.S. Government Printing Office. 1133 p. Accessed in June 2015 at [http://www.deepseadrilling.org/39/volume/dsdp39\\_42.pdf](http://www.deepseadrilling.org/39/volume/dsdp39_42.pdf).
- Mead, J.G. 1989a. Shepherd's beaked whale *Tasmacetus shepherdii* Oliver, 1937. p. 309-320 In: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales. Academic Press, San Diego, CA. 444 p.
- Mead, J.G. 1989b. Beaked whales of the genus *Mesoplodon*. p. 349-430 In: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 4: River dolphins and the larger toothed whales. Academic Press, San Diego, CA. 442 p.
- Mead, J.G. 2009. Shepherd's beaked whale *Tasmacetus shepherdii*. p. 1011-1014 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> edit. Academic Press, San Diego, CA. 1316 p.
- Melcón, M.L., A.J. Cummins, S.M. Kerosky, L.K. Roche, S.M. Wiggins, and J.A. Hildebrand. 2012. Blue whales response to anthropogenic noise. **PLoS ONE** 7(2):e32681. doi:10.1371/journal.pone.0032681.
- Mello, M.R., N. Azambuja, W. Mohriak, A. Catto, and J. Francoli. 2012. Promising giant new hydrocarbon frontier: The Namibian Continental Margin. *GeoExPro* 8(6). Accessed in May 2015 at <http://www.geoexpro.com/articles/2012/03/promising-giant-new-hydrocarbon-frontier-the-namibian-continental-margin>.
- Mikhalev, Y.A., M.V. Ivashin, V.P. Savusin, and F.E. Zelenaya. 1981. The distribution and biology of killer whales in the Southern Hemisphere. **Rep. Int. Whal. Comm.** 31:551-566.

- Miller, G.W., R.E. Elliott, W.R. Koski, V.D. Moulton, and W.J. Richardson. 1999. Whales. p. 5-1 to 5-109 *In*: W.J. Richardson (ed.), Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 390 p.
- Miller, G.W., V.D. Moulton, R.A. Davis, M. Holst, P. Millman, A. MacGillivray, and D. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001–2002. p. 511-542 *In*: S.L. Armsworthy, P.J. Cranford, and K. Lee (eds.), Offshore oil and gas environmental effects monitoring/approaches and technologies. Battelle Press, Columbus, OH. 631 p.
- Miller, I. and E. Cripps. 2013. Three dimensional marine seismic survey has no measureable effect on species richness or abundance of a coral reef associated fish community. **Mar. Poll. Bull.** 77(1-2):63-70.
- Miller, M.H., J. Carlson, P. Cooper, D. Kobayashi, M. Nammack, and J. Wilson. 2014. Status review report: Scalloped hammerhead shark (*Sphyrna lewini*). Final Rep. to the National Marine Fisheries Service. 135 p. Accessed in February 2015 at <http://www.fisheries.noaa.gov/pr/pdfs/statusreviews/scallopedhammerheadshark2014.pdf>.
- Miller, P.J.O., M.P. Johnson, P.T. Madsen, N. Biassoni, M. Quero, and P.L. Tyack. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. **Deep-Sea Res.** 56(7):1168-1181.
- Miller, P.J.O., P.H. Kvadsheim, F.P.A. Lam, P.J. Wensveen, R. Antunes, A.C. Alves, F. Visser, L. Kleivane, P.L. Tyack, and L.D. Sivle. 2012. The severity of behavioral changes observed during experimental exposures of killer (*Orcinus orca*), long-finned pilot (*Globicephala melas*), and sperm whales (*Physeter macrocephalus*) to naval sonar. **Aquat. Mamm.** 38(4):362-401.
- Miyazaki, N. and W.F. Perrin. 1994. Rough-toothed dolphin *Steno bredanensis* (Lesson, 1828). p. 1-21 *In*: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 5: The first book of dolphins. Academic Press, San Diego, CA. 416 p.
- Moein, S.E., J.A. Musick, J.A. Keinath, D.E. Barnard, M. Lenhardt, and R. George. 1994. Evaluation of seismic sources for repelling sea turtles from hopper dredges. Rep. from Virginia Inst. Mar. Sci., Gloucester Point, VA, for U.S. Army Corps of Engineers. 33 p.
- Moore, M.J., S.D. Berrow, B.A. Jensen, P. Carr, R. Sears, V.J. Rowntree, R. Payne, and P.K. Hamilton. 1999. Relative abundance of large whales around South Georgia (1979–1998). **Mar. Mamm. Sci.** 15(4):1287-1302.
- Moore T.C., Jr., P.D. Rabinowitz, P.E. Borella, N.J. Shackleton, and A. Boersma. 1984. DSDP Volume LXXIV: Introduction and explanatory notes. Accessed in May 2015 at [http://www.deepseadrilling.org/74/volume/dsdp74\\_01.pdf](http://www.deepseadrilling.org/74/volume/dsdp74_01.pdf).
- Moreno, I.B., A.N. Zerbini, D. Danilewicz, M.C. de Oliveira Santos, P.C. Simões-Lopes, J. Lailson-Brito Jr., and A.F. Azevedo. 2005. Distribution and habitat characteristics of dolphins of the genus *Stenella* (Cetacea: Delphinidae) in the southwest Atlantic Ocean. **Mar. Ecol. Prog. Ser.** 300:229-240.
- Mortimer, J.A. and A. Carr. 1987. Reproduction and migrations of the Ascension Island green turtle (*Chelonia mydas*). **Copeia** 1987(1):103-113.
- Moulton, V.D. and M. Holst. 2010. Effects of seismic survey sound on cetaceans in the Northwest Atlantic. Environ. Stud. Res. Funds Rep. 182. St. John's, Nfld. 28 p. Accessed in March 2015 at <http://www.esrfunds.org/pdf/182.pdf>.
- Muñoz-Hincapié, M.F., D.M. Mora-Pinto, D.M. Palacios, E.R. Secchi, and A.A. Mignucci-Giannoni. 1998. First osteological record of the dwarf sperm whale in Colombia, with notes on the zoogeography of *Kogia* in South America. **Revista Acad. Colomb. Cien.** 22(84):433-444.

- Nachtigall, P.E. and A.Y. Supin. 2013. A false killer whale reduces its hearing sensitivity when a loud sound is preceded by a warning. **J. Exp. Biol.** 216(16):3062-3070.
- Nachtigall, P.E. and A.Y. Supin. 2014. Conditioned hearing sensitivity reduction in the bottlenose dolphin (*Tursiops truncatus*). **J. Exp. Biol.** 217(15):2806-2813.
- Nachtigall, P.E. and A.Y. Supin. 2015. Conditioned frequency-dependent hearing sensitivity reduction in the bottlenose dolphin (*Tursiops truncatus*). **J. Exp. Biol.** 218(7):999-1005.
- Naro-Maciel, E., J.H. Becker, E.H.S.M. Lima, M.Â. Marcovaldi, and R. DeSalle. 2006. Foraging green sea turtles (*Chelonia mydas*) of Brazil. **J. Hered.** 103(6):792-805.
- Naro-Maciel, E., A.C.V. Bondioli, M. Martin, A.P. Almeida, C. Pabtistotte, C. Bellini, M.Â. Marcovaldi, A.J.B. Santos, and G. Amato. 2012. The interplay of homing and dispersal in green turtles: a focus on the southwestern Atlantic. **J. Hered.** 98(1):29-39.
- NAS-NRC. 1972. Understanding the Mid-Atlantic Ridge. Report of a special workshop held under the auspices of the Ocean Science Committee of the NAS-NRC Ocean Affairs Board January 24–28, 1972. National Academy of Sciences, Washington, D.C. 131 p. Accessed in June 2015 at <https://books.google.ca/books?id=1jYrAAAYAAJ&printsec=frontcover#v=onepage&q&f=false>.
- New, L.F., J. Harwood, L. Thomas, C. Donovan, J.S. Clark, G. Hastie, P.M. Thompson, B. Cheney, L. Scott-Hayward, and D. Lusseau. 2013. Modelling the biological significance of behavioural change in coastal bottlenose dolphins in response to disturbance. **Function. Ecol.** 27(2):314-322.
- Nieukirk, S.L., D.K. Mellinger, S.E. Moore, K. Klinck, R.P. Dziak, and J. Goslin. 2012. Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999–2009. **J. Acoust. Soc. Am.** 131(2):1102-1112.
- NMFS (National Marine Fisheries Service). 2000. Small takes of marine mammals incidental to specified activities: marine seismic-reflection data collection in southern California/Notice of receipt of application. **Fed. Regist.** 65(60, 28 Mar.):16374-16379.
- NMFS (National Marine Fisheries Service). 2001. Small takes of marine mammals incidental to specified activities: oil and gas exploration drilling activities in the Beaufort Sea/Notice of issuance of an incidental harassment authorization. **Fed. Regist.** 66(26, 7 Feb.):9291-9298.
- NMFS (National Marine Fisheries Service). 2013a. Takes of marine mammals incidental to specified activities; marine geophysical survey on the Mid-Atlantic Ridge in the Atlantic Ocean, April 2013, through June 2013. Notice; issuance of an incidental harassment authorization. **Fed. Regist.** 78(72, 15 Apr.):22239-22251.
- NMFS (National Marine Fisheries Service). 2013b. Takes of marine mammals incidental to specified activities; marine geophysical survey in the northeast Atlantic Ocean, June to July 2013. Notice; issuance of an incidental harassment authorization. **Fed. Regist.** 78(109, 6 Jun.):34069-34083.
- NMFS (National Marine Fisheries Service). 2013c. Effects of oil and gas activities in the Arctic Ocean: supplemental draft environmental impact statement. U.S. Depart. Commerce, NOAA, NMFS, Office of Protected Resources. Accessed in June 2015 at [http://www.nmfs.noaa.gov/pr/permits/eis/arctic\\_sdeis.pdf](http://www.nmfs.noaa.gov/pr/permits/eis/arctic_sdeis.pdf).
- NMFS (National Marine Fisheries Service). 2015a. Endangered and threatened marine species under NMFS' jurisdiction. Accessed on 12 May 2015 at <http://www.nmfs.noaa.gov/pr/species/esa/>.
- NMFS (National Marine Fisheries Service). 2015b. Endangered and threatened species; identification of 14 distinct population segments of the humpback whale (*Megaptera novaeangliae*) and proposed revision of species-wide listing; Proposed Rule. **Fed. Regist.** 80(76, 21 Apr.):22304-22356.
- NMFS (National Marine Fisheries Service). 2015c. Green turtle (*Chelonia mydas*). Accessed in May 2015 at <http://www.fisheries.noaa.gov/pr/species/turtles/green.htm>.

- NMFS (National Marine Fisheries Service). 2015d. Candidate and proposed species under the Endangered Species Act (ESA). NOAA Fisheries. Accessed in 12 May 2015 at <http://www.nmfs.noaa.gov/pr/species/esa/candidate.htm>.
- NMFS (National Marine Fisheries Service). 2015e. Scalloped hammerhead shark (*Sphyrna lewini*). Accessed in March 2015 at <http://www.nmfs.noaa.gov/pr/species/fish/scallopedhammerheadshark.htm>.
- NMFS (National Marine Fisheries Service). 2015f. Takes of marine mammals incidental to specified activities; marine geophysical survey in the eastern Mediterranean Sea, November to December, 2015; proposed incidental harassment authorization. **Fed. Regist.** 80(172, 4 Sept.):53624-53689.
- NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2013. Hawksbill turtle (*Eretmochelys imbricata*) 5-year review: summary and evaluation. NMFS Office of Protected Resources, Silver Spring, MD, and USFWS Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL. 91 p.
- NMFS and USFWS (National Marine Fisheries Service and U.S. Fish and Wildlife Service). 2015. Endangered and threatened species; identification and proposed listing of eleven distinct population segments of green sea turtles (*Chelonia mydas*) as endangered or threatened and revision of current listings. **Fed. Regist.** 80(55, 23 Mar.):15272-15337.
- NOAA (National Oceanic and Atmospheric Administration). 2015a. Draft guidance for assessing the effects of anthropogenic sound on marine mammals/Acoustic threshold levels for onset of permanent and temporary threshold shifts. Rev. vers. for Second Public Comment Period, 23 Jul. 2015. 180 p. Accessed in October 2015 at <http://www.nmfs.noaa.gov/pr/acoustics/draft%20acoustic%20guidance%20July%202015.pdf>.
- NOAA (National Oceanic and Atmospheric Administration). 2015b. Marine seismic reflection. NOAA National Centres for Environmental Information. Accessed in May 2015 at <http://www.ngdc.noaa.gov/mgg/seismicreflection/fm0105.html>.
- Nowacek, D.P., L.H. Thorne, D.W. Johnston, and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. **Mammal Rev.** 37(2):81-115.
- Nowacek, D.P., K. Bröker, G. Donovan, G. Gailey, R. Racca, R.R. Reeves, A.I. Vedenev, D.W. Weller, and B.L. Southall. 2013. Responsible practices for minimizing and monitoring environmental impacts of marine seismic surveys with an emphasis on marine mammals. **Aquat. Mamm.** 39(4):356-377.
- Nowacek, D.P., C.W. Clark, P.Mann, P.J.O. Miller, H.C. Rosenbaum, J.S. Golden, M. Jasny, J. Kraska, and B.L. Southall. 2015. Marine seismic surveys and ocean noise: time for coordinated and prudent planning. **Front. Ecol. Environ.** 13(7):378-386. doi:10.1890/130286.
- NRC (National Research Council). 2005. Marine mammal populations and ocean noise/Determining when noise causes biologically significant effects. U.S. Nat. Res. Council, Ocean Studies Board, Committee on characterizing biologically significant marine mammal behavior (Wartzok, D.W., J. Altmann, W. Au, K. Ralls, A. Starfield, and P.L. Tyack). Nat. Acad. Press, Washington, DC. 126 p.
- NSF (National Science Foundation). 2012. Record of Decision for marine seismic research funded by the National Science Foundation. June 2012. 41 p. Accessed in March 2015 at <http://www.nsf.gov/geo/oce/envcomp/rod-marine-seismic-research-june2012.pdf>.
- NSF and USGS (National Science Foundation and U.S. Geological Survey). 2011. Final Programmatic Environmental Impact Statement/Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey. Accessed in March 2015 at <http://www.nsf.gov/geo/oce/envcomp/usgs-nsf-marine-seismic-research/nsf-usgs-final-eis-oeis-with-appendices.pdf>.

- OBIS (Ocean Biogeographic Information System). 2015. Global biodiversity indices from the Ocean Biogeographic Information System. Intergovernmental Oceanographic Commission of UNESCO. Accessed in February 2015 at <http://www.iobis.org>.
- Oddone, M.C., L. Paesch, and W. Norbis. 2005. Reproductive biology and seasonal distribution of *Mustelus schmitti* (Elasmobranchii: Triakidae) in the Rio de la Plata oceanic front, south-western Atlantic. **J. Mar. Biol. Ass. U.K.** 85(5):1193-1198.
- Oddone, M.C., L. Paesch, W. Norbis, and G. Velasco. 2007. Population structure, distribution and abundance patterns of the Patagonian smoothhound *Mustelus schmitti* Springer, 1939 (Chondrichthyes, Elasmobranchii, Triakidae) in the Rio de la Plata and Inner Continental Shelf, SW Atlantic Ocean (34°30'–39°30'S). **Brazil. J. Oceanog.** 55(3):167-177.
- Odell, D.K. and K.M. McClune. 1999. False killer whale *Pseudorca crassidens* (Owen, 1846). p. 213-243 In: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 6: The second book of dolphins and the porpoises. Academic Press, San Diego, CA. 486 p.
- Oliveira, A., C.K.M. Kolesnikovas, P.P. Serafini, L.M.P. Moreira, M. Pontalti, P.C. Simoes-Lopes, and A.S. Barreto. 2011. Occurrence of pinnipeds in Santa Catarina between 2000 and 2010. **LAJAM** 9(2):145-149.
- Olson, P.A. 2009. Pilot whales—*Globicephala melas* and *G. macrorhynchus*. p. 847-852 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> edit. Academic Press, San Diego, CA. 1316 p.
- Otley, H. 2012. The composition of the cetacean community in the Falkland (Malvinas) Islands, southwest South Atlantic Ocean. **Rev. Biol. Mar. Oceanog.** 47(3):537-551.
- Otley, H., J. Smith, and M.L. Dalebout. 2012. Beaked whale strandings on the Falkland Islands and South Georgia, South Atlantic Ocean, between 1866 and 2008. **J. Mar. Biol. Assoc. U.K.** 92(8):1851-1864.
- Papale, E., M. Gamba, M. Perez-Gil, V.M. Martin, and C. Giacoma. 2015. Dolphins adjust species-specific frequency parameters to compensate for increasing background noise. **PLoS ONE** 10(4):e0121711. doi:10.1371/journal.pone.0121711.
- Papi, F., P. Luschi, S. Åkesson, S. Capogrossi, and G.C. Hays. 2000. Open-sea migration of magnetically disturbed sea turtles. **J. Exp. Biol.** 203(22):3435-3443.
- Parks, S.E., M. Johnson, D. Nowacek, and P.L. Tyack. 2011. Individual right whales call louder in increased environmental noise. **Biol. Lett.** 7(1):33-35.
- Parks, S.E., M.P. Johnson, D.P. Nowacek, and P.L. Tyack. 2012. Changes in vocal behaviour of North Atlantic right whales in increased noise. p. 317-320 In: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York, NY. 695 p.
- Parnell, R., B. Verhage, S.L. Deem, H. Van Leeuwe, T. Nishihara, C. Moukoulou, and A. Gibudi. 2007. Marine turtle mortality in southern Gabon and northern Congo. **Mar. Turtle Newsl.** 116:12-14.
- Passadore, C., A. Domingo, M. Szephegyi, and E.R. Secchi. 2014. Influence of environmental and longline fishing operational variables on the presence of killer whales (*Orcinus orca*) in south-western Atlantic. **J. Mar. Biol. Assoc. U.K.** 94(6):1267-1276.
- Passadore, C., A. Domingo, and E.R. Secchi. 2015a. Depredation by killer whale (*Orcinus orca*) and false killer whale (*Pseudorca crassidens*) on the catch of the Uruguayan pelagic longline fishery in southwestern Atlantic Ocean. **ICES J. Mar. Sci.** 72(5):1653-1666. doi:10.1093/icesjms/fsu251.
- Passadore, C., A. Domingo, and E.R. Secchi. 2015b. Analysis of marine mammal bycatch in the Uruguayan pelagic longline fishery operating in the southwestern Atlantic Ocean. **ICES J. Mar. Sci.** 72(5):1637-1652. doi:10.1093/icesjms/fsu250.

- Patenaude, N.J., V.A. Portway, C.M. Schaeff, J.L. Bannister, P.B. Best, R.S. Payne, V.J. Rowntree, M. Rivarola, and C.S. Baker. 2007. Mitochondrial DNA diversity and population structure among southern right whales (*Eubalaena australis*). **J. Heredity** 98(2):147-157.
- Payne, R. 1978. Behavior and vocalizations of humpback whales (*Megaptera* sp.). In: K.S Norris and R.R. Reeves (eds.), Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. MCC-77/03. Rep. from Sea Life Inc., Makapuu Pt., HI, for U.S. Mar. Mamm. Comm., Washington, DC.
- Peña, H., N.O. Handegard, and E. Ona. 2013. Feeding herring schools do not react to seismic air gun surveys. **ICES J. Mar. Sci.** 70(6):1174-1180. doi:10.1093/icesjms/fst079.
- Perez, J.A.A. 2007. Patterns and processes of the ecosystems of the southern Mid-Atlantic Ridge. MAR-ECO Project Workshop, 29–30 Sept. 2007. Reykjavic, Iceland. Accessed in May 2015 at [http://www.mar-eco.no/sci/\\_\\_\\_data/page/886/SA\\_MAR\\_ECO\\_ICELAND.pdf](http://www.mar-eco.no/sci/___data/page/886/SA_MAR_ECO_ICELAND.pdf).
- Perez, J.A.A., E. dos Santos Alves, M.R. Clark, O. Aksel Bergstad, A. Gebruk, I. Azevedo Cardoso, and A. Rogacheva. 2012. Patterns of life on the southern Mid-Atlantic Ridge: compiling what is known and addressing future research. **Oceanography** 25(4):16-31.
- Perrin, W.F. 2009a. Spinner dolphin *Stenella longirostris*. p. 1100-1103 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Perrin, W.F. 2009b. Pantropical spotted dolphin *Stenella attenuata*. p. 819-821 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Perrin, W.F. 2009c. Common dolphins *Delphinus delphis* and *D. capensis*. p. 255-259 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Perrin, W.F. and R.L. Brownell, J. 2009. Minke whales. p. 733-735 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> edit. Academic Press, San Diego, CA. 1316 p.
- Perrin, W.F. and J.W. Gilpatrick, Jr. 1994. Spinner dolphin. p. 99-128 In: S.H. Ridgway and R.J. Harrison (eds.), Handbook of marine mammals, Vol. 5: The first book of dolphins. Academic Press, San Diego, CA. 416 p.
- Perrin, W.F., C.E. Wilson, and F.I. Archer II. 1994. Striped dolphin *Stenella coeruleoalba* (Meyen, 1833). p. 129-159 In: S. H. Ridgway and R. J. Harrison (eds.), Handbook of marine mammals, Vol. 5: The first book of dolphins. Academic Press, San Diego, CA. 416 p.
- Perryman, W.L. 2009. Melon-headed whale *Peponocephala electra*. p. 719-721 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Petersen, S.L., M.B. Honig, P.G. Ryan, L.G. Underhill, and R. Nel. 2008a. Turtle bycatch in the pelagic longline fishery off southern Africa. p. 38-58 In: S. Petersen, D. Nel, P. Ryan, and L. Underhill (eds.), Understanding and mitigating vulnerable bycatch in southern African trawl and longline fisheries. WWF South Africa Report Series—2008/Marine/002. 225 p. Accessed in June 2015 at [http://www.adu.org.za/pdf/Petersen\\_S\\_2008\\_PhD\\_thesis.pdf#page=78](http://www.adu.org.za/pdf/Petersen_S_2008_PhD_thesis.pdf#page=78).
- Petersen, S.L., M.B. Honig, P.G. Ryan, L.G. Underhill, and L.J.V. Compagno. 2008b. Pelagic shark bycatch in the pelagic longline fishery off southern Africa. p. 59-79 In: S. Petersen, D. Nel, P. Ryan, and L. Underhill (eds.), Understanding and mitigating vulnerable bycatch in southern African trawl and longline fisheries. WWF South Africa Report Series—2008/Marine/002. 225 p. Accessed in June 2015 at [http://www.adu.org.za/pdf/Petersen\\_S\\_2008\\_PhD\\_thesis.pdf#page=78](http://www.adu.org.za/pdf/Petersen_S_2008_PhD_thesis.pdf#page=78).

- Pierson, M.O., J.P. Wagner, V. Langford, P. Birnie, and M.L. Tasker. 1998. Protection from, and mitigation of, the potential effects of seismic exploration on marine mammals. Chapter 7 *In*: M.L. Tasker and C. Weir (eds.), Proc. Seismic Mar. Mamm. Worksh., London, U.K., 23–25 June 1998.
- Pinedo, M.C. and T. Polacheck. 2004. Sea turtle by-catch in pelagic longline sets off southern Brazil. **Biol. Conserv.** 119(3):335-339.
- Pinedo, M.C., A.S. Barreto, M.P. Lammardo, A.L.V. Andrade, and L. Geracitano. 2002a. Northernmost records of the spectacled porpoise, Layard's beaked whale, Commerson's dolphin, and Peale's dolphin in the southwestern Atlantic Ocean. **Aquat. Mamm.** 28(1):32-37.
- Pinedo, M.C., T. Polacheck, A.S. Barreto, and M.P. Lammardo. 2002b. A note on vessel of opportunity sighting surveys for cetaceans in the shelf edge region off the southern coast of Brazil. **J. Cetac. Res. Manage.** 4(3):323-329.
- Pinheiro, H.T., A.S. Martins, J.L. Gasparini. 2010. Impact of commercial fishing on Trindade Island and Martin Vaz Archipelago, Brazil: characteristics, conservation status of the species involved and prospects for preservation. **Braz. Arch. Biol. Tech.** 53(6):1417-1423.
- Piniak, W.E.D., D.A. Mann, S.A. Eckert, and C.A. Harms. 2012a. Amphibious hearing in sea turtles. p. 83-88. *In*: A.N. Popper and A. Hawkins (eds.), The effects of noise on aquatic life. Springer, New York. 695 p.
- Piniak, W.E.D., S.A. Eckert, C.A. Harms, and E.M. Stringer. 2012b. Underwater hearing sensitivity of the leatherback sea turtle (*Dermochelys coriacea*): assessing the potential effect of anthropogenic noise. U.S. Dept. of the Interior, Bureau of Ocean Energy Management, Headquarters, Herndon, VA. OCS Study BOEM 2012-01156. 35 p.
- Pirotta, E., R. Milor, N. Quick, D. Moretti, N. Di Marzio, P. Tyack, I. Boyd, and G. Hastie. 2012. Vessel noise affects beaked whale behavior: results of a dedicated acoustic response study. **PLoS ONE** 7(8):e42535. doi:10.1371/journal.pone.0042535.
- Pirotta, E., K.L. Brookdes, I.M. Graham, and P.M. Thompson. 2014. Variation in harbour porpoise activity in response to seismic survey noise. **Biol. Lett.** 10:20131090. doi:10.1098/rsbl.2013.1090.
- Pirotta, E., N.D. Merchant, P.M. Thompson, T.R. Barton, and D. Lusseau. 2015. Quantifying the effect of boat disturbance on bottlenose dolphin foraging activity. **Biol. Conserv.** 181:82-98.
- Pitman, R. 2009. Mesoplodon whales (*Mesoplodon* spp.). p. 721-726. *In*: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Pitman, R.L., A.L. Van Helden, P.B. Best, and A. Pym. 2006. Shepherd's beaked whale (*Tasmacetus shepherdii*): information on appearance and biology based on strandings and at-sea observations. **Mar. Mamm. Sci.** 22(3):744-755.
- Pomilla, C. and H.C. Rosenbaum. 2005. Against the current: an inter-oceanic whale migration event. **Biol. Lett.** 1(4):476-479.
- Popov, V.V., A.Y. Supin, D. Wang, K. Wang, L. Dong, and S. Wang. 2011. Noise-induced temporary threshold shift and recovery in Yangtze finless porpoises *Neophocaena phocaenoides asiaeorientalis*. **J. Acoust. Soc. Am.** 130(1):574-584.
- Popov, V.V., A.Y. Supin, V.V. Rozhnov, D.I. Nechaev, E.V. Sysuyeva, V.O. Klishin, M.G. Pletenko, and M.B. Tarakanov. 2013a. Hearing threshold shifts and recovery after noise exposure in beluga whales, *Delphinapterus leucas*. **J. Exper. Biol.** 216:1587-1596.
- Popov, V., A. Supin, D. Nechaev, and E.V. Sysueva. 2013b. Temporary threshold shifts in naïve and experienced belugas: learning to dampen effects of fatiguing sounds? Abstr. 3<sup>rd</sup> Int. Conf. Effects of Noise on Aquatic Life, Aug. 2013, Budapest, Hungary.

- Popov, V.V., D.I. Nechaev, E.V. Sysueva, V.V. Rozhnov, and A.Y. Supin. 2015. Spectrum pattern resolution after noise exposure in a beluga whale, *Delphinapterus leucas*: evoked potential study. **J. Acoust. Soc. Am.** 138(1):377-388.
- Popper, A.N. 2009. Are we drowning out fish in a sea of noise? **Mar. Sci.** 27:18-20.
- Popper, A.N. and M.C. Hastings. 2009a. The effects of human-generated sound on fish. **Integr. Zool.** 4(1):43-52.
- Popper, A.N. and M.C. Hastings. 2009b. The effects of anthropogenic sources of sound on fishes. **J. Fish Biol.** 75(3):455-489.
- Popper, A.N., T.J. Carlson, J.A. Gross, A.D. Hawkins, D.G. Zeddies, L. Powell, and J. Young. 2013. Effects of seismic airguns on pallid sturgeon and paddlefish. Abstr. 3<sup>rd</sup> Int. Conf. Effects of Noise on Aquatic Life, Aug. 2013, Budapest, Hungary.
- Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Carlson, S. Coombs, W.T. Ellison, R.L. Gentry, M.B. Halvorsen, S. Løkkeborg, P.H. Rogers, B.L. Southall, D.G. Zeddies, and W.N. Tavolga. 2014. Sound exposure guidelines for fishes and sea turtles: a technical report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Springer Briefs in Oceanography. ASA Press—ASA S3/SC1.4 TR-2014. 75 p.
- Pritchard, P.C.H. 1976. Post-nesting movements of marine turtles (Cheloniidae and Dermochelyidae) tagged in the Guianas. **Copeia** 4:749-754.
- Probert, K. 1999. Seamounts, sanctuaries and sustainability: Moving towards deep-sea conservation. **Aquat. Conserv. Mar. Freshw. Ecosyst.** 9(6):601-605.
- Proietti, M.C., P. Lara-Ruiz, J.W. Reisser, L.D.S. Pinto, and O.A. Dellagostin, and L.F. Marins. 2009. Green turtles (*Chelonia mydas*) foraging at Arvoredo Island in Southern Brazil: genetic characterization and mixed stock analysis through mtDNA control region haplotypes. **Genet. Mol. Biol.** 32(3):613-618.
- Proietti, M.C., J.W. Reisser, P.G. Kinas, R. Kerr, D.S. Monteiro, L.F. Marins, and E.R. Secchi. 2012. Green turtle *Chelonia mydas* mixed stocks in the western South Atlantic, as revealed by mtDNA haplotypes and drifter trajectories. **Mar. Ecol. Prog. Ser.** 447:195-209.
- Prosdocimi, L., V. González Carman, D.A. Albareda, and M.I. Remis. 2012. Genetic composition of green turtle feeding grounds in coastal waters of Argentina based on mitochondrial DNA. **J. Exp. Mar. Biol. Ecol.** 412:37-45.
- Prosdocimi, L., P.H. Dutton, D. Albareda, and M.I. Remis. 2014. Origin and genetic diversity of leatherbacks (*Dermochelys coriacea*) at Argentine foraging grounds. **J. Exp. Mar. Biol. Ecol.** 458:13-19.
- Radford, A.N., E. Kerridge, and S.D. Simpson. 2014. Acoustic communication in a noisy world: can fish compete with anthropogenic noise? **Behav. Ecol.** 25(5):1022-1030.
- RAF (Royal Air Force). 2015. Ascension Island. Royal Air Force, U.K. Crown. Accessed in May 2015 at <http://www.raf.mod.uk/currentoperations/opsascension.cfm>.
- Reisinger, R.R. and M.N. Bester. 2010. Long distance breeding dispersal of a southern elephant seal. **Polar Biol.** 33(9):1289-1291.
- Reeves, R.R., B.D. Smith, E.A. Crespo, and G. Notarbartolo di Sciara. 2003. Dolphins, whales, and porpoises: 2002–2010 conservation action plan for the World's cetaceans. IUCN/SSC Cetacean Specialist Group, Gland, Switzerland, and Cambridge, U.K. Accessed in June 2015 at <https://portals.iucn.org/library/efiles/documents/2003-009.pdf>.
- Reeves, R.R., K. McClellan, and T.B. Werner. 2013. Marine mammal bycatch in gillnet and other entangling net fisheries, 1990 to 2011. **Endang. Spec. Res.** 20(1):71-97. doi: 10.3354/esr00481.

- Reis, E.C., L.S. Soares, S.M. Vargas, F.R. Santos, R.J. Young, K.A. Bjørndal, A.B. Bolten, and G. Lôbo-Hajdu. 2010. Genetic composition, population structure and phylogeography of the loggerhead sea turtle: colonization hypothesis for the Brazilian rookeries. **Conserv. Genet.** 11(4):1467-1477.
- Reyes, L.M. 2006. Cetacean distribution in the South Atlantic and South Pacific Ocean. Centro Nacional Patagónico (CENPAT), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina. Retrieved from <http://www.iobis.org>.
- Rice, A.N., J.T. Tielens, B.J. Estabrook, C.A. Muirhead, A. Rahaman, M. Guerra, and C.W. Clark. 2014. Variation of ocean acoustic environments along the western North Atlantic coast: a case study in context of the right whale migration route. **Ecol. Inform.** 21:89-99.
- Rice, D.W. 1998. Marine mammals of the world: systematics and distribution. Spec. Publ. 4. Society for Marine Mammalogy, Allen Press, Lawrence, KS. 231 p.
- Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego, CA. 576 p.
- Richardson, W.J., G.W. Miller, and C.R. Greene, Jr. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. **J. Acoust. Soc. Am.** 106(4, Pt. 2):2281 (Abstract).
- Risch, D., P.J. Corkeron, W.T. Ellison, and S.M. Van Parijs. 2012. Changes in humpback whale song occurrence in response to an acoustic source 200 km away. **PLoS One** 7:e29741. doi:10.1371/journal.pone.0029741.
- Risch, D., P.J. Corkeron, W.T. Ellison, and S.M. Van Parijs. 2014. Formal comment to Gong et al.: Ecosystem scale acoustic sensing reveals humpback whale behavior synchronous with herring spawning processes and re-evaluation finds no effect of sonar on humpback song occurrence in the Gulf of Maine in fall 2006. **PLoS One** 9(10):e109225. doi:10.1371/journal.pone.0109225.
- Rivas-Zinno, F. 2012. Captura incidental de tortugas marinas en Bajos del Solis, Uruguay. Universidad de la Republica Uruguay, Departamento de Ecología y Evolución. Accessed in June 2015 at <https://www.colibri.udelar.edu.uy/bitstream/123456789/1470/1/uy24-15973.pdf>.
- Robertson, F.C., W.R. Koski, T.A. Thomas, W.J. Richardson, B. Würsig, and A.W. Trites. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. **Endang. Species Res.** 21(2):143-160.
- Rogers, A.D. 1994. The biology of seamounts. **Adv. Mar. Biol.** 30:305-350.
- Rogers, A.D. and M. Gianni. 2010. The implementation of UNGA Resolutions 61/105 and 64/72 in the management of deep-sea fisheries on the high-seas. Rep. for the Deep Sea Conservation Coalition, International Programme on the State of the Ocean, London, UK. 97 p. Accessed in June 2015 at <http://www.stateoftheocean.org/pdfs/61105-Implemention-finalreport.pdf>.
- Rolland, R.M., S.E. Parks, K.E. Hunt, M. Castellote, P.J. Corkeron, D.P. Nowacek, S.K. Water, and S.D. Kraus. 2012. Evidence that ship noise increases stress in right whales. **Proc. R. Soc. B** 279(1737):2363-2368.
- Rose, B. and A.I.L. Payne. 1991. Occurrence and behavior of the southern right whale dolphin *Lissodelphis peronii* off Namibia. **Mar. Mamm. Sci.** 7(1):25-34.
- Rosenbaum, H.C., S.M. Maxwell, F. Kershaw, and B. Mate. 2014. Long-range movement of humpback whales and their overlap with anthropogenic activity in the South Atlantic Ocean. **Conserv. Biol.** 28(2):604-615.
- Rosenbaum, H.C., C. Pomilla, M. Mendez, M.S. Leslie, P.B. Best, K.P. Findlay, G. Minton, P.J. Ersts, T. Collins, M.H. Engel, S.L. Bonatto, D.P.G.H. Kotze, M. Meyer, J. Barendse, M. Thornton, Y. Razafindrakoto, S. Ngouessono, M. Vely, and J. Kiszka. 2009. Population structure of humpback whales from their breeding grounds in the South Atlantic and Indian oceans. **PLoS ONE** 4(10):e7318. doi:10.1371/journal.pone.0007318.

- Rowntree, V.J., R.S. Payne, and D.M. Schell. 2001. Changing patterns of habitat use by southern right whales (*Eubalaena australis*) on their nursery ground at Península Valdés, Argentina, and in their long-range movements. **J. Cetac. Res. Manage. (Spec. Iss.)** 2:133-143.
- Rowntree, V.J., M.M. Uhart, M. Sironi, A. Chirife, M. Di Martino, L. La Sala, L. Musmeci, N. Mohamed, J. Andrejuk, D. McAloose, J.E. Sala, A. Carribero, H. Rally, M. Franco, F.R. Adler, R.L. Brownell Jr., J. Seger, and T. Rowles. 2013. Unexplained recurring high mortality of southern right whale *Eubalaena australis* calves at Península Valdés, Argentina. **Mar. Ecol. Prog. Ser.** 493:275-289.
- RPS. 2014a. Final environmental assessment for seismic reflection scientific research surveys during 2014 and 2015 in support of mapping the U.S. Atlantic seaboard extended continental margin and investigating tsunami hazards. Rep. from RPS for United States Geological Survey, August 2014. Accessed in February 2015 at <http://www.nsf.gov/geo/oce/envcomp/usgssurveyfinalea2014.pdf>.
- RPS. 2014b. Draft protected species mitigation and monitoring report: U.S. Geological Survey 2-D seismic reflection scientific research survey program: mapping the U.S. Atlantic seaboard extended continental margin and investigating tsunami hazards, in the northwest Atlantic Ocean, Phase 1, 20 August 2014–13 September 2014, R/V *Marcus G. Langseth*. Rep. from RPS, Houston, TX, for Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY.
- RPS. 2015. Protected species mitigation and monitoring report: East North American Margin (ENAM) 2-D seismic survey in the Atlantic Ocean off the coast of Cape Hatteras, North Carolina, 16 September–18 October 2014, R/V *Marcus G. Langseth*. Rep. from RPS, Houston, TX, for Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY.
- Rudolph, P. and C. Smeenk. 2009. Indo-West Pacific marine mammals. p. 608-616 *In*: W.F. Perrin, B. Würsig and J.G.M. Thewissen (eds.), *Encyclopedia of marine mammals*, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Sale, A. and P. Luschi. 2009. Navigational challenges in the oceanic migrations of leatherback sea turtles. **Proc. R. Soc. B** 276(1674):3737-3745.
- Sairanen, E.E. 2014. Weather and ship induced sounds and the effect of shipping on harbor porpoise (*Phocoena phocoena*) activity. M.Sc. Thesis, University of Helsinki. Accessed in September 2015 at [https://helda.helsinki.fi/bitstream/handle/10138/153043/Gradu\\_SairanenEeva\(1\).pdf?sequence=1](https://helda.helsinki.fi/bitstream/handle/10138/153043/Gradu_SairanenEeva(1).pdf?sequence=1).
- Salden, D.R. 1993. Effects of research boat approaches on humpback whale behavior off Maui, Hawaii, 1989–1993. p. 94 *In*: Abstr. 10<sup>th</sup> Bienn. Conf. Biol. Mar. Mamm., Nov. 1993, Galveston, TX. 130 p.
- Sales, G., B.B. Giffoni, F.N. Fiedler, V.G. Azevedo, J.E. Kotas, Y. Swimmer, and L. Bugoni. 2010. Circle hook effectiveness for the mitigation of sea turtle bycatch and capture of target species in a Brazilian pelagic longline fishery. **Aquat. Conserv. Mar. Fresh. Ecosyst.** 20(4):428-436.
- Samaii, T., P.B. Best, and M.J. Gibbons. The taxonomic status of common dolphins *Delphinus* spp. in South African waters. **Afr. J. Mar. Sci.** 27(2):449-458.
- SAUP (Sea Around Us Project). 2011a. High seas—Atlantic, southeast. Sea Around Us Project—Fisheries, Ecosystems & Biodiversity. The PEW Charitable Trusts. Accessed in May 2015 at <http://www.seaaroundus.org/highsea/47.aspx>.
- SAUP (Sea Around Us Project). 2011b. High seas – Atlantic, Southwest. Sea Around Us Project - Fisheries, Ecosystems & Biodiversity. The PEW Charitable Trusts. Accessed in May 2015 at <http://www.seaaroundus.org/highsea/41.aspx>.
- SAUP (Sea Around Us Project). 2015. Primary production for high seas – Atlantic, Southeast. Accessed in May 2015 at <http://www.seaaroundus.org/LME2/PPTable.aspx?LME=0&FAO=47&country=High%20seas%20-%20Atlantic,%20Southeast>.

- SEAFO (South East Atlantic Fisheries Organization). 2014a. Convention area. Accessed in May 2015 at <http://www.seafo.org/About/Convention-Area>.
- SEAFO (South East Atlantic Fisheries Organization). 2014b. Convention text. Accessed in May 2015 at SEAFO <http://www.seafo.org/About/Convention-Text>.
- SEAFO (South East Atlantic Fisheries Organization). 2014c. VME protection. Accessed in May 2015 at <http://www.seafo.org/Management/VME-Protection>.
- SEAFO (South East Atlantic Fisheries Organization). 2014d. Conservation Measure 28/14: On total allowable catches and related conditions for Patagonian toothfish, and deep-sea red crab for 2015, alfonsino, orange roughy and pelagic armourhead for 2015 & 2016 in the SEAFO Convention Area. 2 p. Accessed in April 2015 at <http://www.seafo.org/Science>.
- SEAFO (South East Atlantic Fisheries Organization). 2014e. Southern boarfish. Southeast Atlantic Fisheries Organization. Accessed in April 2015 at <http://www.seafo.org/Science/Species-Summary/Southern-Boarfish>.
- SEAFO (South East Atlantic Fisheries Organization). 2015. VME Map. SEAFO, Swakopmund, Namibia, and Food and Agriculture Organization of the United Nations (FAO). Accessed in April 2015 at <http://www.seafo.org/Science/VME-Map#>
- Sears, R. and W.F. Perrin. 2009. Blue whale *Balaenoptera musculus*. p. 120-124 In: W.F. Perrin, B. Würsig and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Sekiguchi, K., N.T.W. Klages, and P.B. Best. 1995. Stomach contents of a southern bottlenose whale, *Hyperoodon planifrons*, stranded at Heard Island. **Mar. Mamm. Sci.** 11(4):575-584.
- Seminoff, J.A., C.D. Allen, G.H. Balazs, P.H. Dutton, T. Eguchi, H.L. Haas, S.A. Hargrove, M. Jensen, D.L. Klemm, A.M. Lauritsen, S.L. MacPherson, P. Opay, E.E. Possardt, S. Pultz, E. Seney, K.S. Van Houtan, and R.S. Waples. 2015. Status review of the green turtle (*Chelonia mydas*) under the Endangered Species Act. NOAA-TM-NMFS-SWFSC-539. 571 p.
- Sergeant, D.E. 1977. Stocks of fin whales *Balaenoptera physalus* L. in the North Atlantic Ocean. **Rep. Int. Whal. Comm.** 27:460-473.
- Shaughnessy, P.D. and G.J.B. Ross. 1980. Records of the subantarctic fur seal (*Arctocephalus tropicalis*) from South Africa with notes on its biology and some observations of captive animals. **Ann. S. Afr. Mus.** 82(1-7):71-89. Accessed in June 2015 at <http://www.biodiversitylibrary.org/item/126521#page/8/mode/1up>.
- Shirshov Institute. n.d. The census of marine life project: South Atlantic MAR ECO. Cruise #1\_2009 R/V *Akademik Ioffe*, 25 October–29 November 2009. Academy of Sciences, Shirshov Institute, Russia. 10 p. Accessed in June 2015 at [http://www.mar-eco.no/sci/\\_\\_\\_data/page/992/SA\\_MAR-ECO\\_Cruise\\_1-2009\\_Summary\\_Report.pdf](http://www.mar-eco.no/sci/___data/page/992/SA_MAR-ECO_Cruise_1-2009_Summary_Report.pdf).
- Shipboard Scientific Party. 2003. Leg 208 preliminary report—Early Cenozoic extreme climates: The Walvis Ridge transect 6 March–6 May 2003. Ocean Drilling Program, Prelim. Rep. 108. Texas A&M University, College Station, TX. 117 p. Accessed in May 2015 at [http://www-odp.tamu.edu/publications/prelim/208\\_prel/208toc.html#pdf](http://www-odp.tamu.edu/publications/prelim/208_prel/208toc.html#pdf).
- Siciliano, S., M.C.O. Santos, A.F.C. Vicente, F.S. Alvarenga, E. Zampiroli, J.L. Brito Jr., A.F. Azevedo, and J.L.A. Pizzorno. 2004. Strandings and feeding records of Bryde's whales (*Balaenoptera edeni*) in southeastern Brazil. **J. Mar. Biol. Assoc. UK** 84(4):857-859.
- Siciliano, S., J.F. de Moura, H.R. Filgueiras, P.P. Rodrigues, and N. de Oliveira Leite, Jr. 2012. Sightings of humpback whales on the Vitória-Trindade Chain and around Trindade Island. **Braz. J. Oceanog.** 60(3):455-459.

- Sidorovskaia, N., B. Ma, A.S. Ackleh, C. Tiemann, G.E. Ioup, and J.W. Ioup. 2014. Acoustic studies of the effects of environmental stresses on marine mammals in large ocean basins. p. 1155 *In: AGU Fall Meeting Abstracts*, Vol. 1. Accessed in June 2015 at <https://agu.confex.com/agu/fm14/meetingapp.cgi#Paper/10591>.
- Simard, Y., F. Samaran, and N. Roy. 2005. Measurement of whale and seismic sounds in the Scotian Gully and adjacent canyons in July 2003. p. 97-115 *In: K. Lee, H. Bain, and C.V. Hurley (eds.), Acoustic monitoring and marine mammal surveys in The Gully and outer Scotian Shelf before and during active seismic surveys. Environ. Stud. Res. Funds Rep.* 151. 154 p. (Published 2007).
- Sivle, L.D., P.H. Kvadsheim, A. Fahlman, F.P.A. Lam, P.L. Tyack, and P.J.O. Miller. 2012. Changes in dive behavior during naval sonar exposure in killer whales, long-finned pilot whales, and sperm whales. **Front. Physiol.** 3(400). doi:10.3389/fphys.2012.00400.
- Solé, M., M. Lenoir, M. Durfort, M. López-Bejar, A. Lombarte, M. van der Schaaer, and M. André. 2013. Does exposure to noise from human activities compromise sensory information from cephalopod statocysts? **Deep-Sea Res. II** 95:160-181.
- Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. **Aquat. Mamm.** 33(4):411-522.
- Southall, B.L., T. Rowles, F. Gulland, R.W. Baird, and P.D. Jepson. 2013. Final report of the Independent Scientific Review Panel investigating potential contributing factors to a 2008 mass stranding of melon-headed whales (*Peponocephala electra*) in Antsohihy, Madagascar. Accessed in March 2015 at <http://iwc.int/2008-mass-stranding-in-madagascar>.
- Southwestern Pacific OBIS. 2014. British Antarctic ("Terra Nova") Expedition, 1910–1913. Southwestern Pacific OBIS, National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand, 1679 records, Online <http://nzobisipt.elasticbeanstalk.com/resource.do?r=terranova> released on July 29, 2014. Retrieved from <http://www.iobis.org>.
- Souza de Carvalho, M. and M.R. Rossi-Santos. 2011. Sightings of the bottlenose dolphins (*Tursiops truncatus*) in the Trindade Island, Brazil, South Atlantic Ocean. **Mar. Biod. Rec.** 4:e15. doi:10.1017/S1755267211000029.
- Spieß, V., S. Krastel, B. Beitler, W. Böke, A. Gerriets, F. Heidersdorf, J. Leupold, M. Salem, F. Schruöter, T. Schwenk, R. Zahn-Knoll, and L. Zuhisdröff. 2003. Report and preliminary results of *Meteor* cruise M49/1 Cape Town (South Africa)–Montevideo (Uruguay) 04.01.2000–10.02.2000. Ber., Fachbereich Geowiss., Univ. Bremen, 205. 57 p. Accessed in June 2015 at <http://elib.suub.uni-bremen.de/ip/docs/00010324.pdf>
- Stevens, J. 2005. Porbeagle shark *Lamna nasus* (Bonnaterre, 1788). p. 262-234 *In: S.L. Fowler, R.D. Cavanagh, M. Camhi, G.H. Burgess, G.M. CAilliet, S.V. Fordham, C.A. Simpfendorfer, and J.A. Musick (eds.), Sharks, rays and chimaeras: the status of the Chondrichthyan fishes. IUCN/SSC Shark Specialist Group.* Accessed in June 2015 at <https://portals.iucn.org/library/efiles/documents/2005-029.pdf>.
- Stevick, P.T., L.P. Godoy, M. McOsker, M.H. Engle, and J. Allen. 2006. A note on the movement of a humpback whale from Abrolhos Bank, Brazil to South Georgia. **J. Cetac. Res. Manage.** 8(3):297-300.
- Stevick, P.T., M.C. Neves, F. Johansen, M.H. Engel, J. Allen, M.C.C. Marcondes, and C. Carlson. 2011. A quarter of a world away: female humpback whale moves 10,000 km between breeding areas. **Biol. Lett.** 7(2):299-302.
- Stone, C.J. 2015. Marine mammal observations during seismic surveys from 1994–2010. JNCC Rep. No. 463a. 64 p.
- Stone, C.J. and M.L. Tasker. 2006. The effects of seismic airguns on cetaceans in U.K. waters. **J. Cetac. Res. Manage.** 8(3):255-263.

- Thomé, J.C.A., C. Baptistotte, L.M. de P. Moreira, J.T. Scalfoni, A.P. Almeida, D.B. Rieth, and P.C.R. Barata. 2007. Nesting biology and conservation of the leatherback sea turtle (*Dermochelys coriacea*) in the state of Espírito Santo, Brazil. **Chel. Conserv. Biol.** 6:15-27.
- Thompson, D., M. Sjöberg, E.B. Bryant, P. Lovell, and A. Bjørge. 1998. Behavioural and physiological responses of harbour (*Phoca vitulina*) and grey (*Halichoerus grypus*) seals to seismic surveys. p. 134 *In*: Abstr. 12<sup>th</sup> Bienn. Conf. World Mar. Mamm. Sci. Conf., 20–25 Jan., Monte Carlo, Monaco. 160 p.
- Thompson, K., C.S. Baker, A. van Helden, S. Patel, C. Millar, and R. Constantine. 2012. The worlds' rarest whale. **Current Biol.** 22(21):R905-R906.
- Thompson, P.M., K.L. Brookes, I.M. Graham, T.R. Barton, K. Needham, G. Bradbury, and N.D. Merchant. 2013. Short-term disturbance by a commercial two-dimensional seismic survey does not lead to long-term displacement of harbour porpoises. **Proc. Royal Soc. B** 280:20132001. doi:10.1098/rspb.2013.2001.
- Tolstoy, M., J. Diebold, L. Doermann, S. Nooner, S.C. Webb, D.R. Bohnstiehl, T.J. Crone, and R.C. Holmes. 2009. Broadband calibration of R/V *Marcus G. Langseth* four-string seismic sources. **Geochem. Geophys. Geosyst.** 10:Q08011. doi:10.1029/2009GC002451.
- Tormosov, D.D., Y.A. Mikhalev, P.B. Best, V.A. Zemsky, K. Sekiguchi, and R.L. Brownell, Jr. 1998. Soviet catches of southern right whales *Eubalaena australis*, 1951–1971. Biological data and conservation implications. **Biol. Conserv.** 86(2):185-197.
- Tougaard, J., A.J. Wright, and P.T. Madsen. 2015. Cetacean noise criteria revisited in light of proposed exposure limits for harbour porpoises. **Mar. Poll. Bull.** 90(1-2):196-208.
- Tyack, P.L. and V.M. Janik. 2013. Effects of noise on acoustic signal production in marine mammals. p. 251-271 *In*: H. Brumm (ed.), Animal communication and noise. Springer, Berlin, Heidelberg, Germany. 453 p.
- Tyack, P.L., W.M.X. Zimmer, D. Moretti, B.L. Southall, D.E. Claridge, J.W. Durban, C.W. Clark, A. D'Amico, N. DiMarzio, S. Jarvis, E. McCarthy, R. Morrissey, J. Ward, and I.L. Boyd. 2011. Beaked whales respond to simulated and actual navy sonar. **PLoS One** 6(e17009). doi:10.1371/journal.pone.0017009.
- UNEP-WCMC (United Nations Environment Programme-World Conservation Monitoring Centre). 2015. Convention on International Trade in Endangered Species of Wild Flora and Fauna. Appendices I, II, and III. Valid from 5 February 2015. Accessed on 9 February 2015 at <http://www.cites.org/eng/app/appendices.php>.
- UNESCO-WHC (United Nations Educational, Scientific and Cultural Organization World Heritage Convention). 2015a. The Mid-Atlantic Ridge. Accessed on 21 May at <http://whc.unesco.org/en/activities/504/>.
- UNESCO-WHC (United Nations Educational, Scientific and Cultural Organization World Heritage Convention). 2015b. Gough and Inaccessible Islands. Accessed in May 2015 at <http://whc.unesco.org/en/list/740>.
- USCG (U.S. Coast Guard). 2013. AMVER density plot display. USCG, U.S. Department of Homeland Security. Accessed in April 2015 at <http://www.amver.com/density.asp>.
- van Helden, A.L., A.N. Baker, M.L. Dalebout, J.C. Reyes, K. Van Waerebeek, and C.S. Baker. 2002. Resurrection of *Mesoplodon traversii* (Gray, 1874), senior synonym of *M. bahamondi* Reyes, Van Waerebeek, Cárdenas and Yáñez, 1995 (Cetacea: Ziphiidae). **Mar. Mamm. Sci.** 18(3):609-621.
- Van Waerebeek, K., A. Djiba, J.-O. Krakstad, A.S.O. Bilal, I.L. Bamy, A. Almeida, and E.M. Mbye. 2013. New evidence for a South Atlantic stock of humpback whales wintering on the northwest African Continental Shelf. **African Zool.** 48(1):177-186.
- Vargas, S.M., F.C.F. Araújo, D.S. Monteiro, S.C. Estima, A.P. Almeida, L.S. Soares, and F.R. Santos. 2008. Genetic diversity and origin of leatherback turtles (*Dermochelys coriacea*) from the Brazilian coast. **J. Hered.** 99(2):215-220.

- Vélez-Rubio, G.M., A. Estrades, A. Fallabrino, and J. Tomás. 2013. Marine turtle threats in Uruguayan waters: insights from 12 years of stranding data. **Mar. Biol.** 160(11):2797-2811. doi: 10.1007/s00227-013-2272-y.
- Vighi, M., A. Borrell, E.A. Crespo, L.R. Oliveira, P.C. Simões-Lopes, P.A.C. Flores, N.A. García, and A. Aguilar. 2014. Stable isotopes indicate population structuring in the southwest Atlantic population of right whales (*Eubalaena australis*). **PLoS ONE** 9(3):e90489. doi:10.1371/journal.pone.0090489.
- Vögler, R., A.C. Milessi, and R.A. Quiñones. 2003. Trophic ecology of *Squatina guggenheim* on the continental shelf off Uruguay and northern Argentina. **J. Fish Biol.** 62(6):1254-1267.
- Wade, P.R. and T. Gerrodette. 1993. Estimates of cetacean abundance and distribution in the eastern tropical Pacific. **Rep. Int. Whal. Comm.** 43:477-493.
- Wang, M.C., W.A. Walker, K.T. Shao, and L.S. Chou. 2002. Comparative analysis of the diets of pygmy sperm whales and dwarf sperm whales in Taiwanese waters. **Acta Zool. Taiwan** 13(2):53-62.
- Waring, G.T., L. Nottestad, E. Olsen, H. Skov, and G. Vikingsson. 2008. Distribution and density estimates of cetaceans along the Mid-Atlantic Ridge during summer 2004. **J. Cetac. Res. Manage.** 10(2):137-146.
- Wartzok, D., A.N. Popper, J. Gordon, and J. Merrill. 2004. Factors affecting the responses of marine mammals to acoustic disturbance. **Mar. Technol. Soc. J.** 37(4):6-15.
- Wedekin, L.L., M.R. Rossi-Santos, C. Baracho, A.L. Cypriano-Souza, and P.C. Simões-Lopes. 2014. Cetacean records along a coastal-offshore gradient in the Vitória-Trindade Chain, western South Atlantic Ocean. **Braz. J. Biol.** 74(1):137-144.
- Weilgart, L.S. 2007. A brief review of known effects of noise on marine mammals. **Int. J. Comp. Psychol.** 20(2):159-168.
- Weilgart, L.S. 2014. Are we mitigating underwater noise-producing activities adequately? A comparison of Level A and Level B cetacean takes. Working pap. SC/65b/E07. Int. Whal. Comm., Cambridge, U.K. 17 p.
- Weir, C.R. 2007a. Occurrence and distribution of cetaceans off northern Angola, 2004/05. **J. Cetac. Res. Manage.** 9(3):225-239.
- Weir, C.R. 2007b. Observations of marine turtles in relation to seismic airgun sound off Angola. **Mar. Turtle Newsl.** 116:17-20.
- Weir, C.R. 2010. A review of cetacean occurrence in West African waters from the Gulf of Guinea to Angola. **Mammal Rev.** 40(1):2-39.
- Weir, C.R. and S.J. Dolman. 2007. Comparative review of the regional marine mammal mitigation guidelines implemented during industrial seismic surveys, and guidance towards a worldwide standard. **J. Int. Wildl. Law Policy** 10(1):1-27.
- Weir, C.R., T. Ron, M. Morais, and A.D.C. Duarte. 2007. Nesting and at-sea distribution of marine turtles in Angola, West Africa, 2000–2006: occurrence, threats and conservation implications. **Oryx** 41(2):224–231.
- Weir, C.R., J. Debrah, P.K. Ofori-Danson, C. Pierpoint, and K. Van Waerebeek. 2008. Records of Fraser's dolphin *Lagenodelphis hosei* Fraser 1956 from the Gulf of Guinea and Angola. **Afr. J. Mar. Sci.** 30(2):241-246.
- Weir, C.R., T. Collins, I. Carvalho, and H.C. Rosenbaum. 2010. Killer whales (*Orcinus orca*) in Angolan and Gulf of Guinea waters, tropical West Africa. **J. Mar. Biol. Assoc. U.K.** 90(8):1601-1611.
- Wells, R.S. and M.D. Scott. 2009. Common bottlenose dolphin *Tursiops truncatus*. p. 249-255 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- Wensveen, P.J., L.A.E. Huijser, L. Hoek, and R.A. Kastelein. 2014. Equal latency contours and auditory weighting functions for the harbour porpoise (*Phocoena phocoena*). **J. Exp. Biol.** 217(3):359-369.

- Wensveen, P.J., A.M. von Benda-Beckmann, M.A. Ainslie, F.P.A. Lam, P.H. Kvadsheim, P.L. Tyack, and P.J.O. Miller. 2015. How effectively do horizontal and vertical response strategies of long-finned pilot whales reduce sound exposure from naval sonar? **Mar. Environ. Res.** 106:68-81.
- White, R.W., K.W. Gillon, A.D. Black, and J.B. Reid. 2002. The distribution of seabirds and marine mammals in Falkland Islands waters. Joint Nature Conservation Committee Report. 106 p. Accessed in June 2015 at [http://jncc.defra.gov.uk/PDF/pubs02\\_Falklands.pdf](http://jncc.defra.gov.uk/PDF/pubs02_Falklands.pdf).
- Whitehead, H. 2002. Estimates of the current global population size and historical trajectory for sperm whales. **Mar. Ecol. Prog. Ser.** 242:295-304.
- Whitehead, H. 2009. Sperm whale *Physeter macrocephalus*. p. 1091-1097 In: W.F. Perrin, B. Würsig, and J.G.M. Thewissen (eds.), Encyclopedia of marine mammals, 2<sup>nd</sup> ed. Academic Press, San Diego, CA. 1316 p.
- WildEarth Guardians. 2013. Petition to list eighty-one marine species under the Endangered Species Act. Report submitted acting through the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, to the U.S. Secretary of Commerce. 538 p. Accessed in February 2015 at [http://www.nmfs.noaa.gov/pr/species/petitions/81\\_multi\\_species\\_marine\\_petition\\_2013.pdf](http://www.nmfs.noaa.gov/pr/species/petitions/81_multi_species_marine_petition_2013.pdf).
- Williams, A.J., S.L. Petersen, M. Goren, and B.P. Watkins. 2009. Sightings of killer whales *Orcinus orca* from longline vessels in South African waters, and consideration of the regional conservation status. **Afr. J. Mar. Sci.** 31(1):81-86.
- Williams, R., S.L. Hedley, and P.S. Hammond. 2006. Modeling distribution and abundance of Antarctic baleen whales using ships of opportunity. **Ecol. Soc.** 11(1): 1. [online] Accessed in June 2015 at <http://www.ecologyandsociety.org/vol11/iss1/art1/>.
- Williams, T.M., W.A. Friedl, M.L. Fong, R.M. Yamada, P. Sideivy, and J.E. Haun. 1992. Travel at low energetic cost by swimming and wave-riding bottlenose dolphins. **Nature** 355(6363):821-823.
- Willis, K.L., J. Christensen-Dalsgaard, D.R. Ketten, and C.E. Carr. 2013. Middle ear cavity morphology is consistent with an aquatic origin for testudines. **PLoSOne** 8(1):e54086. doi:10.1371/journal.pone.0054086.
- Wilson, J.W., M.-H. Burle, and M.N. Bester. 2006. Vagrant Antarctic pinnipeds at Gough Island. **Polar Biol.** 29(10):905-908.
- Winn, H.E. and N.E. Reichley. 1985. Humpback whale *Megaptera novaeangliae* (Borowski, 1781). p. 241-273 In: S.H. Ridgway and R. Harrison (eds.), Handbook of marine mammals, Vol. 3: The sirenia and baleen whales. Academic Press, London, U.K. 362 p.
- Witt, M.J., B. Baert, A.C. Broderick, A. Formia, J. Fretey, A. Gibudi, G.A.M. Mounquengui, C. Moussounda, S. Nougessono, R.J. Parnell, D. Roumet, G.-P. Sounguet, B. Verhage, A. Zogo, and B.J. Godley. 2009. Aerial surveying of the world's largest leatherback turtle rookery: a more effective methodology for large-scale monitoring. **Biol. Conserv.** 142(8):1719-1727.
- Witt, M.J., E.A. Bonguno, A.C. Broderick, M.S. Coyne, A. Formia, A. Gibudi, G.A.M. Mounquengui, C. Moussounda, M. Nsafou, S. Nougessono, R.J. Parnell, G.-P. Sounguet, S. Verhage, and B.J. Godley. 2011. Tracking leatherback turtles from the world's largest rookery: assessing threats across the South Atlantic. **Proc. R. Soc. B** 278(1716):2338-2347. doi:10.1098/rspb.2010.2467.
- Wittekind, D., J. Tougaard, P. Stilz, M. Dähne, K. Lucke, C.W. Clark, S. von Benda-Beckmann, M. Ainslie, and U. Siebert. 2013. Development of a model to assess masking potential for marine mammals by the use of airguns in Antarctic waters. Abstr. 3<sup>rd</sup> Int. Conf. Effects of Noise on Aquatic Life, Aug. 2013, Budapest, Hungary.
- Wole, O.G. and E.F. Myade. 2014. Effect of seismic operations on cetaceans sightings off-shore Akwa Ibom State, south-south, Nigeria. **Int. J. Biol. Chem. Sci.** 8(4):1570-1580.

- Wright, A.J. 2014. Reducing impacts of human ocean noise on cetaceans: knowledge gap analysis and recommendations. 98 p. World Wildlife Fund Global Arctic Programme, Ottawa, Ont.
- Wright, A.J. and L.A. Kyhn. 2014. Practical management of cumulative anthropogenic impacts for working marine examples. **Conserv. Biol.** 29(2):333-340. doi:10.1111/cobi.12425.
- Wright, A.J., T. Deak, and E.C.M. Parsons. 2011. Size matters: management of stress responses and chronic stress in beaked whales and other marine mammals may require larger exclusion zones. **Mar. Poll. Bull.** 63(1-4):5-9.
- Würsig, B., S.K. Lynn, T.A. Jefferson, and K.D. Mullin. 1998. Behaviour of cetaceans in the northern Gulf of Mexico relative to survey ships and aircraft. **Aquat. Mamm.** 24(1):41-50.
- Würsig, B., T.A. Jefferson, and D.J. Schmidly. 2000. The marine mammals of the Gulf of Mexico. Texas A&M University Press, College Station, TX. 232 p.
- Yazvenko, S.B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, S.K. Meier, H.R. Melton, M.W. Newcomer, R.M. Nielson, V.L. Vladimirov, and P.W. Wainwright. 2007a. Distribution and abundance of western gray whales during a seismic survey near Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):45-73.
- Yazvenko, S.B., T.L. McDonald, S.A. Blokhin, S.R. Johnson, H.R. Melton, and M.W. Newcomer. 2007b. Feeding activity of western gray whales during a seismic survey near Sakhalin Island, Russia. **Environ. Monit. Assess.** 134(1-3):93-106.
- Zerbini, A.N. and J.E. Kotas. 1998. A note on cetacean bycatch in pelagic driftnetting off southern Brazil. **Rep. Int. Whal. Comm.** 48:519-524.
- Zerbini, A.N., A. Andriolo, M.-P. Heide-Jørgensen, J.L. Pizzorno, Y.G. Maia, G.R. VanBlaricom, D.P. DeMaster, P.C. Simões-Lopes, S. Moreira, and C. Bethlem. 2006. Satellite-monitored movements of humpback whales *Megaptera novaeangliae* in the southwest Atlantic Ocean. **Mar. Ecol. Prog. Ser.** 313:295-304.
- Zerbini, A.N., A. Andriolo, M.-P. Heide-Jørgensen, S.C. Moreira, J.L. Pizzorno, Y.G. Maia, G.R. VanBlaricom, and D.P. DeMaster. 2011. Migration and summer destinations of humpback whale (*Megaptera novaeangliae*) in the western South Atlantic Ocean. **J. Cetac. Res. Manage. (Spec. Iss.)** 3:113-118.